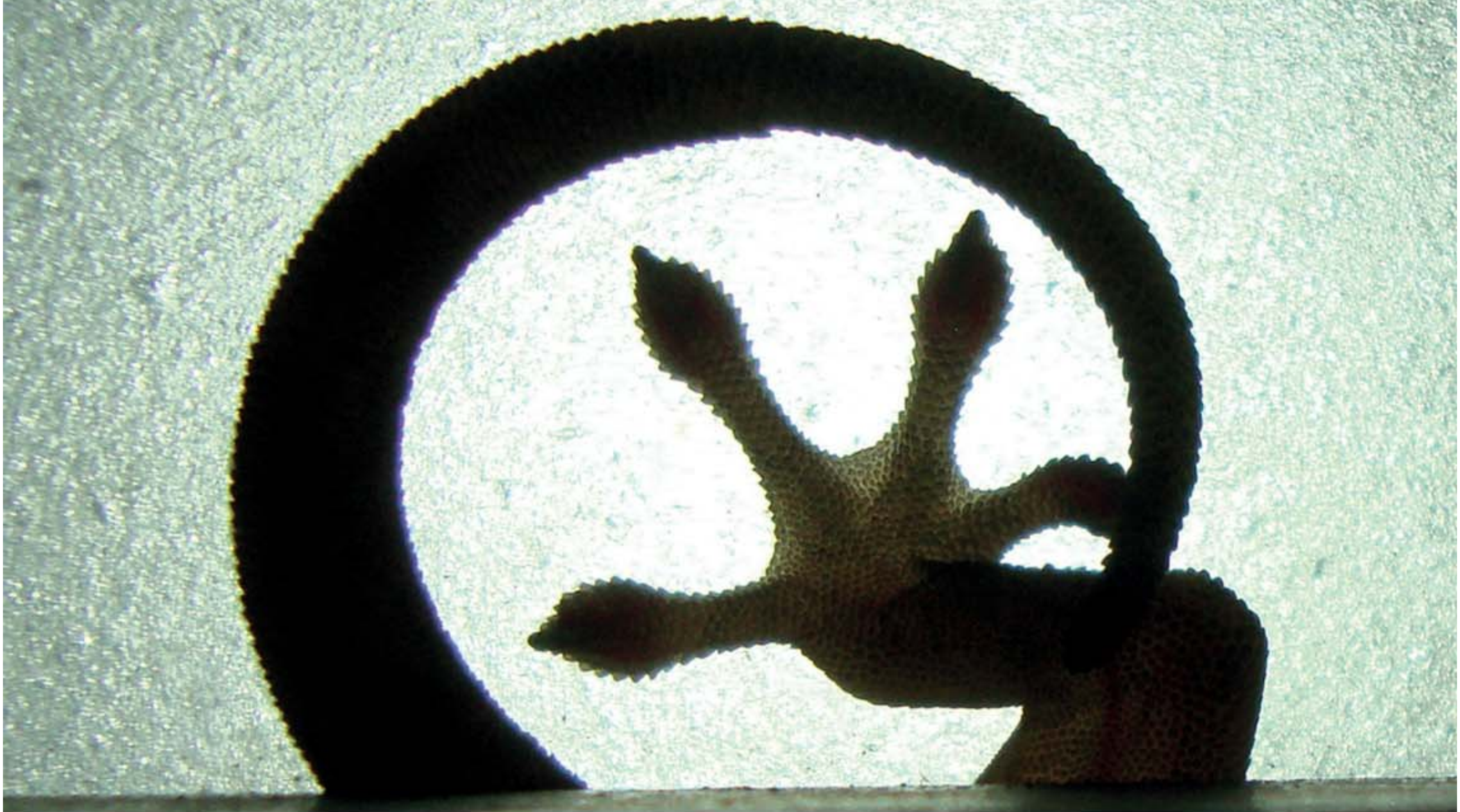
First
General Action Meeting
COST ACTION CA 15216

ENBA

European Network of Bioadhesion Expertise

Fundamental Knowledge to Inspire Advanced Bonding Technologies



6 - 7 March 2017
Natural History Museum, Vienna, Austria

Organised by

Janek von Byern
Ludwig Boltzmann Institute for Experimental and Clinical Traumatology
Austria

Norbert Cyran
University of Vienna
Austria

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

T.C.C.
Trauma Care Consult

Time table

Monday 06.03.2017

09:00	**Museum Opening** and **Registration**
09:30-10:00	**Opening Speeches** Stanislav **Gorb** - Action Chair Germany Nicole **Schmidt** - FFG Austria Heinz **Redl** - Grant Holder Institution Austria
10:00-10:10	Presentation of Nicholas **Aldred** (MC UK and WG 1 leader)
Morning Session Chairwomen: Romana Santos and Seda Kizilel	
10:10-10:20	Presentation of Jose Miguel **Martin-Martinez** (MC Spain)
10:20-10:30	Presentation of Ute **Rothbächer** (MC-S Austria)
10:30-10:40	Presentation of Gabriel **Furtos** (MC Romania)
10:40-10:50	Presentation of Päivi **Laaksonen** (MC Finland)
10:50-11:00	Presentation of Pavlo **Bekhta** (NNC Ukraine)
11:00-11:30	**Coffee break** and **Poster session**
11:30-11:40	Presentation of Tomaž **Pepelnjak** (MC Slovenia)
11:40-11:50	Presentation of Sylvia **Nürnberger** (MC Austria)
11:50-12:00	Presentation of Michal **Zurovec** (MC Czech Republic)
12:00-12:10	Presentation of Havazelet **Bianco-Peled** (MC Israel)
12:10-12:20	Presentation of Federico **Bosia** (MC-S Italy)
12:20-12:30	Presentation of Patrick **Flammang** (MC Belgium and STSM Coordinator)
12:30 -14:00	**Lunch break** and **Poster Session**
Afternoon Session Chair(wo)man: Stanislav Gorb and Sylvia Nürnberger	
14:00-14:10	Presentation of Simone **Dimartino** (MC UK)
14:10-14:20	Presentation of Claire **Hellio** (MC France)
14:20-14:30	Presentation of Alejandro **Sosnik** (MC-S Israel)
14:30-14:40	Presentation of Marianne **Hiorth** (MC Norway)
14:40-14:50	Presentation of Tomasz **Krystofiak** (MC Poland)
14:50-15:00	Presentation of Marleen **Kamperman** (MC Netherlands)
15:00-15:30	**Coffee break** and **Poster Session**
15:30-15:40	Presentation of Manfred **Penning** (Participant Germany)
15:40-15:50	Presentation of João **Mano** (MC Portugal)
15:50-16:00	Presentation of Josette **Camilleri** (MC Malta)
16:00-16:10	Presentation of Thomas **Ederth** (MC Sweden)
16:10-16:20	Presentation of Nibedita **Saha** (MC-S Czech Republic)
16:20-16:30	Presentation of Jon **Barnes** (Participant UK)
16:30-16:40	Presentation of Lucia **Forzia** (COST Belgium)
16:40-18:40	**MC Meeting** and **Poster Session**
19:00 - 22:00	**Icebreaker Party**
22:00	**Official Meeting Closure**

MC = Management Committee member ; **MC-S** = Management Committee substitute ; **NNC** = Near Neighbour Country

Tuesday 07.03.2017

09:00	**Museum Opening & Registration**
09:20-09:30	**Opening Speech** Romana **Santos** – Vice Action Chair Portugal
09:30-10.00	**Keynote Talk** Haesin **Lee** (Participant South Korea)
10:10-10:20	Presentation of Seda **Kizilel** (MC Turkey and WG 2 leader)
Morning Session Chairwomen: Claire Hellio and Päivi Laaksonen	
10:20-10:30	Presentation of Henrik **Birkedahl** (MC Denmark)
10:30-10:40	Presentation of Ingunn **Tho** (MC Norway)
10:40-10:50	Presentation of Meir **Haber** (MC Israel)
10:50-11:00	Presentation of Matthias **Berglin** (MC Sweden)
11:00-11:40	**Coffee break** and **Poster session**
11:40-11:50	Presentation of Andras **Dinnyes** (MC Hungary)
11:50-12:00	Presentation of Elisa **Hennebert** (MC Belgium)
12:00-12:10	Presentation of Jaroslav **Katona** (MC Serbia)
12:10-12:20	Presentation of Marco **Faimali** (MC Italy)
12:20-12:30	Presentation of Nabanita **Saha** (MC Czech Republic)
12:30-12:40	Presentation of Anne Marie **Power** (MC Ireland and WG 3 leader)
12:40-14:00	**Lunch break** and **Poster Session**
Afternoon Session Chairman: Nicholas Aldred	
14:00-14:10	Presentation of Pedro **Fardim** (MC-S Belgium)
14:10-14:20	Presentation of Urška Vrabič **Brodnjak** (MC Slovenia)
14:20-14:30	Presentation of Sergei **Vlassov** (MC Estonia)
14:30-14:40	Presentation of Ebru Toksoy **Oner** (MC Turkey)
14:40-14:50	Presentation of Peter **Ladurner** (MC-S Austria)
14:50-15:00	Presentation of Arita **Dubnika** (MC Latvia)
15:00-15:40	**Coffee break** and **Poster Session**
15:40-16:20	**Task leader selection**
16:20-17:00	**Open Discussion**
17:00	**Official Meeting Closure**

Foyer event

Date: 06.03. 2017
Time: 09:30 to 15:00
Location: Foyer of the Natural History Museum
Target groups: Museum visitors, mainly children and teens
Aim of the event: Presentation of biological diversity of dry and wet adhesives and their practical applications

The local organiser will show live and model examples of animals (snails, salamander, flies, ...) and plants (orchids, carnivores) which use adhesives for attachment, for defence or prey capture. Furthermore, medical, industrial and cosmetic applications based on bioadhesives (kidney glue, fibrin, self-healing polymer, Gecko-Tape) will be shown and their basic principles explained during this event.

Examples of hazardous products from medicine, industry and cosmetics will be exhibited and their health risks explained.

All meeting participants are encouraged and welcomed to participate and contribute on this Foyer event, speak with the museum visitors about their work in bioadhesives research and support the local organiser in promoting this COST Action to the public.

Participant list

Last name	First name	Institute	Country	Email	Academic/ Company	ECI
Aldred	Nicholas	Newcastle University	United Kingdom	nicholas.aldred@ncl.ac.uk	Academic	
Athanasiadou	Eleftheria	Chimar Hellas SA	Greece	eathan@ari.gr	Company	
Badalamenti	Fabio	Institute for the Coastal and Marine Environment	Italy	fabio.badalamenti@cnr.it	Academic	
Barnes	Jon	University of Glasgow	United Kingdom	Jon.Barnes@glasgow.ac.uk	Academic	Yes
Baudis	Stefan	Technical University Wien	Austria	Stefan.baudis@tuwien.ac.at	Academic	Yes
Bekhta	Pavlo	Ukrainian National Forestry University	Ukraine	bekhta@ukr.net	Academic	
Bennemann	Michael	Westphalian Institute for Biomimicry	Germany	michael.bennemann@w-hs.de	Academic	Yes
Berglin	Mattias	SP Technical Research Institute of Sweden	Sweden	Mattias.berglin@sp.se	Academic	
Bianco-Peled	Havazelet	Technion	Israel	bianco@technion.ac.il	Academic	
Birkedal	Henrik	Aarhus University	Denmark	hbirkedal@chem.au.dk	Academic	
Boateng	Joshua	University of Greenwich	United Kingdom	j.s.boateng@gre.ac.uk	Academic	
Bonneel	Marie	Research Institute for Biosciences	Belgium	marie.bonneel@student.umons.ac.be	Academic	Yes
Borodich	Feodor	Cardiff University	United Kingdom	borodichfm@cardiff.ac.uk	Academic	
Bosia	Federico	University of Torino	Italy	fbosia@unito.it	Academic	
Butikova	Jelena	Institute of Solid State Physics	Latvia	but@latnet.lv	Academic	Yes
Camilleri	Josette	University of Malta	Malta	josette.camilleri@um.edu.mt	Academic	
Clare	Anthony	Newcastle University	United Kingdom	tony.clare@ncl.ac.uk	Academic	
Conlan	Sheelagh	Liverpool John Moores University	United Kingdom	S.L.Conlan@ljmu.ac.uk	Academic	Yes
Correal Mòdol	Eduard	Forest Sciences Centre of Catalonia	Spain	eduard.correal@incafust.cat	Academic	Yes
Cyran	Norbert	University of Vienna	Austria	norbert.cyran@univie.ac.at	Academic	
Dimartino	Simone	University of Edinburgh	United Kingdom	Simone.Dimartino@ed.ac.uk	Academic	Yes
Dinnyes	Andras	Biotalentum LTD	Hungary	Andras.dinnyes@biotalentum.hu	Company	
Dobeš	Pavel	Masaryk University	Czech Republic	pavel.dobes.sci@gmail.com	Academic	Yes
Dolic	Olivera	University of Banja Luka	Bosnia and Herzegovina	oliveradolicilic@gmail.com	Academic	
Dorrer	Victoria	Technical University Wien	Austria	victoria.dorrer@gmail.com	Academic	

Dubnika	Arita	Riga Technical University	Latvia	arita.dubnika@rtu.lv	Academic	Yes
Dworak	Claudia	Technical University Wien	Austria	Claudia.dworak@tuwien.ac.at	Academic	Yes
Ederth	Thomas	Linköping University	Sweden	ted@ifm.liu.se	Academic	
Faimali	Marco	Istituto di Scienze Marine – CNR	Italy	marco.faimali@ismar.cnr.it	Academic	
Fardim	Pedro	KU Leuven	Belgium	pedro.fardim@kuleuven.be	Academic	
Farkas	Robert	Slovak Academy of Sciences	Slovakia	ueenfark@savba.sk	Academic	
Flammang	Patrick	University of Mons	Belgium	Patrick.Flammang@umons.ac.be	Academic	
Fras Zemlic	Lidija	University Maribor	Slovenia	Lidija.fras@um.si	Academic	
Furtos	Gabriel	Raluca Ripan Institute of Research in Chemistry	Romania	gfurtos@yahoo.co.uk	Academic	
Gorb	Stanislav	University of Kiel	Germany	sgorb@zoologie.uni-kiel.de	Academic	
Gorb	Elena	Kiel University	Germany	egorb@zoologie.uni-kiel.de	Academic	
Haber	Meir	Biota Ltd	Israel	meir@algawish.com	Company	
Hellio	Claire	Université de Bretagne Occidentale	France	claire.hellio@univ-brest.fr	Academic	
Hennebert	Elisa	University of Mons	Belgium	elise.hennebert@umons.ac.be	Academic	Yes
Hiorth	Marianne	School of Pharmacy, University of Oslo	Norway	marianne.hiorth@farmasi.uio.no	Academic	
Hyrsl	Pavel	Masaryk University	Czech Republic	hyrsl@sci.muni.cz	Academic	
Ivankovic	Alojz	University College Dublin	Ireland	alojz.ivankovic@ucd.ie	Academic	
Kamperman	Marleen	Wageningen University	Netherlands	marleen.kamperman@wur.nl	Academic	
Katona	Jaroslav	Faculty of Technology Novi Sad	Serbia	jkatona@uns.ac.rs	Academic	
Kizilel	Seda	KOC University	Turkey	skizilel@ku.edu.tr	Academic	
Kojic	Zeljka	University of Banja Luka	Bosnia and Herzegovina	zeljka.kojic@yahoo.com	Academic	
Kovacevic	Davor	University of Zagreb	Croatia	davor.kovacevic@chem.pmf.hr	Academic	
Krystofiak	Tomasz	Poznan University of Life Sciences	Poland	tomkrys@up.poznan.pl	Academic	
Laaksonen	Päivi	Aalto University	Finland	paivi.laaksonen@aalto.fi	Academic	Yes
Ladurner	Peter	University of Innsbruck	Austria	peter.ladurner@uibk.ac.at	Academic	
Langowski	Julian	Wageningen University	Netherlands	julian.langowski@wur.nl	Academic	Yes
Lee	Haeshin	Korea Advanced Institute of Sci. & Tech.	South Korea	haeshin@kaist.ac.kr	Academic	

Lefevre	Mathilde	Research Institute for Biosciences	Belgium	mathilde.lefevre@umons.ac.be	Academic	Yes
Lengerer	Birgit	University Innsbruck	Austria	birgit.lengerer@uibk.ac.at	Academic	
Mano	João	University of Aveiro	Portugal	jmano@ua.pt	Academic	
Marchesan	Silvia	University of Trieste	Italy	smarchesan@units.it	Academic	Yes
Marchetti-Deschmann	Martina	Technical University Wien	Austria	martina.marchetti-deschmann@tuwien.ac.at	Academic	
Martin-Martinez	Jose Miguel	University of Alicante-Adhesion and Adhesives Laboratory	Spain	jm.martin@ua.es	Academic	
McElhatton	Anna	University of Malta	Malta	anna.mcelhatton@um.edu.mt	Academic	
Nitschke	Jonathan	University of Cambridge	United Kingdom	jrn34@cam.ac.uk	Academic	
Nürnberger	Sylvia	Medical University of Vienna	Austria	Sylvia.Nuernberger@meduniwien.ac.at	Academic	Yes
Palomo	Jose M	Institute of Catalysis (CSIC)	Spain	josempalomo@icp.csic.es	Academic	
Pavan	Giovanni	University of Applied Science of Southern Switzerland	Switzerland	giovanni.pavan@supsi.ch	Academic	
Penk	Michael	Beilstein-Institut	Germany	mpenk@beilstein-institut.de	Others	
Penning	Manfred	PennConsult	Germany	mhp.shellac@t-online.de	Company	
Pepelnjak	Tomaž	University of Ljubljana	Slovenia	tomaz.pepelnjak@fs.uni-lj.si	Academic	
Pjeta	Robert	University Innsbruck	Austria	robert.pjeta@uibk.ac.at	Academic	
Poulsen	Nicole	TU Dresden	Germany	poulsen@bcube-dresden.de	Academic	
Power	Anne Marie	National University of Ireland Galway	Ireland	annemarie.power@nuigalway.ie	Academic	
Redl	Heinz	Ludwig Boltzmann Institute for Experimental and Clinical Traumatology	Austria	Office@trauma.lbg.ac.at	Academic	
Reis	Catarina	ULHT/ECTS	Portugal	catarinapintoreis@gmail.com	Academic	Yes
Rodrigues	Marcelo	University Innsbruck	Austria	marcelo.rodrigues@uibk.ac.at	Academic	Yes
Rothbächer	Ute	University Innsbruck	Austria	ute.rothbaecher@uibk.ac.at	Academic	
Saha	Nabanita	Tomas Bata University in Zlin	Czech Republic	nabanitas@cps.utb.cz	Academic	Yes
Saha	Nibedita	Tomas Bata University in Zlin	Czech Republic	nibedita@uni.utb.cz	Academic	
Santos	Romana	Marine and Environmental Sciences Lisbon Centre and CQB	Portugal	romana.santos@campus.ul.pt	Academic	

Sedliacik	Jan	Technical University in Zvolen	Slovakia	sedliacik@tuzvo.sk	Academic	
Sionkowska	Alina	Nicolaus Copernicus University in Torun	Poland	as@chem.umk.pl	Academic	
Slezak	Paul	Ludwig Boltzmann Institute for Experimental and Clinical Traumatology	Austria	paul.slezak@trauma.lbg.ac.at	Academic	
Sosnik	Alejandro	Technion	Israel	alesosnik@gmail.com	Academic	
Tho	Ingunn	University of Oslo	Norway	ingunn.tho@farmasi.uio.no	Academic	
Tilbury	Maura	National University of Ireland Galway	Ireland	m.tilbury1@nuigalway.ie	Academic	Yes
Toksoy Oner	Ebru	Institute of Technology	Turkey	ebru.toksoy@marmara.edu.tr	Academic	
Tomoaia-Cotisel	Maria	Babes-Bolyai University of Cluj-Napoca	Romania	mcotisel.chem.ubbcluj.ro@gmail.com	Academic	Yes
Van Leeuwen	Johan	Wageningen University and Research	Netherlands	johan.vanleeuwen@wur.nl	Academic	
Vlassov	Sergei	University of Tartu	Estonia	vlassovs@ut.ee	Academic	Yes
Voigt	Dagmar	Technische Universität Dresden	Germany	dagmarvoigt@web.de	Academic	
Voinova	Svetlana	COST	Belgium	Svetlana.Voinova@cost.eu	Others	
von Byern	Janek	Ludwig Boltzmann Institute for Experimental and Clinical Traumatology	Austria	vByern@freenet.de	Academic	
Vrabič Brodnjak	Urška	University of Ljubljana	Slovenia	urska.vrabic@ntf.uni-lj.si	Academic	
Webb	David	Newcastle University	UK	D.Webb3@newcastle.ac.uk	Academic	
Werner	Dalal	Aérial	France	da.werner@aerial-crt.com	Company	
Wunderer	Julia	University Innsbruck	Austria	julia.wunderer@uibk.ac.at	Academic	
Wyrwa	Ralf	Innovent e.V.	Germany	rw1@innovent-jena.de	Academic	
Zurovec	Michal	Biology Centre CAS	Czech Republic	zurovec@entu.cas.cz	Academic	

Colour Code:

MC member
MC substitute
Meeting participant

Abstracts
Management Committee members

Aldred **Nicholas** **United Kingdom**

Academic Newcastle University

nicholas.aldred@ncl.ac.uk

Dr Aldred is the UK Managing Committee representative, a Working Group leader and Executive Board member of COST Action CA15216 (ENBA). He is currently a Research Fellow at Newcastle University (UK) based in the School of Marine Science and Technology's Biofouling Laboratory (https://research.ncl.ac.uk/biofouling/).

Marine biofouling is the accumulation of unwanted animals and plants on man-made structures at sea and is a multi-billion €/year challenge. To assist in the development of antifouling technologies, the Biofouling Laboratory accommodates fundamental and applied research projects that target the settlement and adhesion of marine fouling organisms.

Working closely with colleagues from diverse disciplines across the natural sciences, Dr Aldred has developed a portfolio of research interests spanning the biochemical composition of biological adhesives, their interfacial interactions with surfaces, physical properties and the behaviours used by organisms to facilitate adhesion underwater.

The laboratory has developed an advanced capability for laboratory-scale evaluation of developmental antifouling coatings, including cultures of numerous invertebrate and plant species, quantitative settlement and behavioural assays, and hydrodynamic/mechanical methods for investigating adhesion under operationally relevant conditions.

Current funders include EC FP7, the US Office of Naval Research, the UK Ministry of Defence (DSTL) and significant industrial collaborations.

Athanasiadou Eleftheria Greece

Company Chimar Hellas SA

eathan@ari.gr

From ancient times adhesives from plants and animals have been used for several gluing applications including the gluing of wood. After the 60s these bio-based adhesives were replaced by adhesives synthesised from petrochemicals due to cost, durability and availability factors.

More recently, the environmental problems caused by the use of petrochemicals and the increases in oil prices have renewed the interest on bio-based adhesives.

CHIMAR HELLAS has over 20years R&D expertise and know-how on producing bio-based adhesive systems derived from renewable biomass products, natural materials and natural products, bio-based wastes and by-products.

Bio-based adhesives of CHIMAR have been evaluated in the production of composite wood panels at the lab and pilot scale and the most successful ones at the industrial scale, in direct comparison with commercial adhesives.

Berglin **Mattias** **Sweden**

Academic SP Technical Research Institute of Sweden

Mattias.berglin@sp.se

Many marine organisms are surprisingly free of biofouling although lacking chemical defence. Instead the surface microstructure has been suggested to have a deterioration effect on organism settling and adhesion. The common theme among these organisms is the surface structuring on a hierarchical length scale ranging from 1-300 µm.

The potential suite of surfaces to be mimicked or adapted has not been fully utilised, mainly due to limiting manufacturing techniques preventing production of surface structures on a hierarchical length scales. The advent of new technologies within 3D-scanning/3D-printing now open novel opportunities to investigate the presence of patterned surfaces that may prevent biofouling based on physical interference.

We aim to use such a biomimetic approach to elucidate mechanisms of action and to generate predictive models to develop bio-inspired antifouling technologies.

Bianco-Peled **Havazelet** **Israel**

Academic Technion – Israel Institute of Technology

bianco@technion.ac.il

Prof. Havazelet Bianco-Peled is an expert in the area of bioadhesion and biomedical polymers. She has received several awards for her professional accomplishments.

She has written about 90 research publications, edited a book and has ten patent applications either granted or pending. Bianco-Peled is the founder and CSO of SEAlantis Ltd., a company that develops, manufactures and commercialize novel biomimetic tissue adhesives base on a technology invented in her lab.

The Company recived a CE mark for Seal-V™, a protein-free bioresorbable sealant intended to achieve hemostasis in surgical reconstruction of large blood vessels. A second clinical trial in the field of GI sealing is carried out these days.

Her current research interests include: mucoadhesion, tissue adhesives, nano-materials for biomedical applications, drug delivery, physical characterization of biological, biomedical and biomimetic nano-systems.

Birkedal **Henrik** **Denmark**

Academic Aarhus University

hbirkedal@chem.au.dk

Inspired by the byssus of the blue mussel, we have synthesized a range of materials based on two of the salient chemical motifs in mussel foot proteins: catechols from DOPA and amines from lysine.

We have made polymers containing such groups. By reacting these polymers with iron or other hard trivalent metal ions, self-healing hydrogels result with pH-dependent mechanical properties. By adjusting the oxidation ability of the DOPA analogue used in our artificial materials, we obtain control over the ratio of covalent and coordination chemistry crosslinking.

These molecules can also be used for the formation of coacervates that provide an excellent platform for very strong adhesives.

Boateng **Joshua** **United Kingdom**

Academic University of Greenwich

j.s.boateng@gre.ac.uk

I am attending the COST ENBA Action meeting as UK MC Substitute as its overall objectives fit within my major research interests in terms of biopharmaceutical applications of bioadhesive drug delivery systems.

I have more than 15 years of academic research experience spanning the interface of chemistry, biology and materials/biomaterial science including pharmaceutical sciences and natural products testing, with particular emphasis in advanced wound healing and mucosal drug delivery systems employing film and wafer technologies.

Current research include multifuctional medicated dressings for infected chronic leg and diabetic foot ulcers, nicotine replacement therapy, formulations for paediatric / geriatric patients and ocular drug delivery. I collaborate with industry and clinical researchers in various multi-disciplinary projects aimed at improving current therapeutic benefit to patients.

I employ a range of formulation and analytical techniques within my faculty including automated freeze-drying machine, XRD, SEM, TEM, NMR, Mass spectrometry, ATR-FTIR, confocal microscope and tissue culture facilities.

Borodich **Feodor** **United Kingdom**

Academic Cardiff University

BorodichFM@cardiff.ac.uk

Nano-world is the '*Sticky Universe*'. The classical JKR or JKRS (Johnson-Kendall-Roberts-Sperling) theory of adhesive contact proposes methodologies to predict the adhesion force between spherical indenters (paraboloids of revolution).

It has been shown that the JKR contact theory can be extended to arbitrary blunt axisymmetric indenters and to materials having rotational symmetry like transversely isotropic or homogeneously prestressed materials [1]. Similar approach is also valid for probing of stretched graphene membranes [2]. The relations between the load, the contact radius and the displacements in adhesive contact for power-law shaped probes reduced to very simple universal dimensionless equations.

[1] Borodich, F.M. (2014) The Hertz-type and adhesive contact problems for depth-sensing indentation. *Advances in Applied Mechanics*, 47, 225-366.

[2] Borodich F.M. and Galanov B.A. (2016) Contact probing of stretched membranes and adhesive interactions: Graphene and other two-dimensional materials. Proc. R. Soc A, 472, 2016.0550

Bosia **Federico** **Italy**

Academic University of Torino

fbosia@unito.it

Adhesion of biological attachment structures, such as the contact units of geckos, beetles or mussels, is usually described by adopting thin film peeling theories based on Kendall theory, due to their “tape-like” geometry.

It relies on Griffith energy balance delamination criteria that describe at macroscopic scale the mechanism of fracture taking place at the micro or nano scales in the vicinity of the crack front, or “peeling line”.

We propose an analytical and numerical approach to model the stress distribution in the interface between the tape and substrate to better understand the delamination process and obtain the load distribution in a fibrillar system, including hierarchical contacts splitting.

The influence on the peeling force of the system on contact unit size and load distributions is discussed.

Butikova **Jelena** **Latvia**

Academic Institute of Solid State Physics

but@latnet.lv

Metal nanowires and nanoparticles have become popular objects for various studies and different applications. Metal nanodumbbells, a “hybrid” of a nanowire and nanoparticles, have recently raised interest as an experimental object in nanomanipulations.

We present a novel method of laser conditioning of metal nanowires in order to transform them into the nanodumbbell structures. As a result of the absorption of the laser pulse energy, the thermal gradient occurs causing the initiation of the melting process at the ends of the nanowires.

The formation of the near-spherical end bulbs follows by the cooling of the nanowire down and rapid solidification and crystallisation of the dumbbell. The proposed method offers an effective and reliable way to produce metal nanodumbbells from the metal nanowires. After the laser processing, both the end bulbs and the connecting nanowire of a metal nanodumbbell preserve their crystallinity.

Camilleri **Josette** **Malta**

Academic University of Malta

josette.camilleri@um.edu.mt

I am a dental surgeon by profession with a doctoral degree in materials. I am a clinician with a practice limited to restorative dentistry with particular focus on endodontics (root canal treatment). My research is mainly concerned with development of materials for dental and medical applications from construction materials. Over the past decade we have characterized a number of materials available clinically mostly used during endodontic surgery and also studied their interaction with tooth structure, tissue fluids and blood. Chemical changes within the material and also the bonding method are assessed.

Our research group also develops new custom-made materials with specific characteristics. We perform characterization by scanning electron microscopy, energy dispersive spectroscopy and elemental mapping, X-ray diffraction analyses and Fourier transform infrared spectroscopy. Interfacial characteristics are also assessed and biological properties at the cellular and tissue level investigated using cells derived form patients and also with animal models.

We also research other materials like dental ceramics and metal alloys. We also have some interest in microbiology. The work is performed together with other departments at the University of Malta and also by joint research programs with several international collaborators.

Correal Mòdol **Eduard** **Spain**

Academic Forest Sciences Centre of Catalonia

eduard.correal@incafust.cat

Eduard Correal Mòdol currently holding a position at the Catalan Institute of Wood part of the Forest Sciences Centre of Catalonia.

The main research of the institution is focused on the characterization of Mediterranan species of softwoods and hardwoods and the development of engineered wood products. Other main goal is to promote the use of timber on construction.

Furthermore, nowadays the most common adhesives are derivatives of the petroleum and the biobased adhesives are the key for producing fully recyclable and ecological wood products.

At the Incafust we have large experience on testing glued timber (Glued Laminated Timber, Cross Laminated Timber, Veneer …) and analysing the issues that adhesives commonly have with the wood products. Finding adhesives that can cope better with the shrinkage and the swelling caused by variation of moisture due to the weathering is also another goal.

Dimartino **Simone** **United Kingdom**

Academic University of Edinburgh

simone.dimartino@ed.ac.uk

In this talk, I will offer an overview of my past research on bioadhesives and current development in other research areas where the biological adhesive community might benefit.

Experimental data on the characterization of the biological adhesives produced by large seaweed will be first presented. After an introduction on the experimental system of interest, particular focus will be given on the experimental techniques employed to perform the morphological, biochemical and mechanical characterization. This includes microscopy, spectroscopy and flow channel measurements.

In the second part of this presentation, current capabilities and trends in 3D printing will be covered. 3D printing is nowadays employed in a number of applications, and experiences a continuous growth in other seemingly unrelated area. This contribution will prompt ideas on the use of this new disruptive technique also in the bioadhesives arena.

Dinnyes **Andras** **Hungary**

Company Biotalentum LTD

Andras.dinnyes@biotalentum.hu

Biotalentum is an RTD intensive SME established in 2005, focused mostly on stem cell research and services, with a branch on EU project management and trainings. BIOT's scientific focus is on medical and animal biotechnologies, recently focusing on stem cell research (human, mouse, rabbit iPSCs, embryonic stem cells and cancer stem cells, 2D and 3D patient specific iPSCs-derived neuronal, cardiac and other cell types).

The company's mission is the development of novel human cellular systems and animal models for biomedical research and drug testing, and to provide technical services for the pharmaceutical industry. The research team of BIOT is comprised of 22 researchers and technical personnel. In FP7 BIOT has successfully participated in 17 projects, being the scientific coordinator in 9 of those projects.

BIOT runs professional courses in a number of areas of interest to researchers including Linking Science to Business, Fundraising for Research and product development: Public and private funding; national and international resources, Principles of intellectual property rights and comparison between Europe / US / Asia, Communication with media, public & policy makers, Scientific writing for papers and doctoral thesis, Gender mainstreaming in science, Management of multicultural research teams, Research project management, Self-Marketing, Conflict Management, Personal Career development plan, Communication and Presentation skills, Team Leadership, Self-Management, Time Management & Organisation of the different components of a PhD project, Ethics in biomedical research, Laboratory animal technologies and animal welfare in EU projects to name but a few.

Dolic **Olivera** **Bosnia and Herzegovina**

Academic University of Banja Luka

oliveradolicilic@gmail.com

My name is Olivera Dolic, and I work as Teaching Assistant on Department of Pediatric and Preventive Dentistry, Medical faculty, University of Banja Luka, B&H. My colleague Zeljka Kojic and I work on research in field of herpes virus infections.

Our research is based on clinically treating efflorescence incurred recurrent herpes infection using reactive protein fibrin from venous blood of the host.
We take biopsy material from the center of efflorescence on the lips and in the mouth of patients before and after the application reactive protein fibrin.
In the microbiology laboratory, the ELISA test determines cytokines therapeutic response.

Clinically we determine the time interval of healing the efflorescence.
The aim of the research is that by using reactive protein fibrin reduces the time interval of vesicles, when people are carriers of the herpes simplex virus, but also to improve the quality of life of people with recurrent herpes infection.

Dubnika **Arita** **Latvia**

Academic Riga Technical University

arita.dubnika@rtu.lv

Rudolfs Cimdins Riga Biomaterials Innovations and Development Centre (RBIDC) is a part of Riga Technical University (Latvia). The RBIDC research team is composed of chemists, chemical engineers and materials scientists.

Currently at RBIDC scientists are working on well-defined research areas for bone tissue replacement and regeneration. Materials such as calcium phosphate ceramics and bone cements as well as phosphate glasses and glass-ceramics are historically developed research areas in RBIDC for more than 15 years.

Biomaterials developed at RBIDC have been tested in clinical practice with more than 400 patient cases in cooperation with clinicians from Riga Stradins University (Latvia).

Additional research fields include hybrid biomaterials, such as, calcium phosphate and polymer composites, microencapsulation of biologically active substances, bimodal porous calcium phosphate bioceramic scaffolds for controlled drug delivery etc.

Ederth **Thomas** **Sweden**

Academic Linköping University

ted@ifm.liu.se

Organisms secreting adhesives for temporary or permanent attachment use a wide range of chemical strategies, which might include secretion of components with different functions, or chemical changes during attachment.

These processes might also depend on environmental factors, or surface properties. Informed development of biomimetic adhesives, or antifouling strategies, relies on a detailed understanding of the chemical changes taking place at the interface.

Areas such as biochemistry and proteomics have contributed considerably in this field, but a full understanding of bioadhesion also requires in-situ monitoring and chemical characterization of the dynamics of adhesion processes.

We describe a set of imaging tools that are capable of in-situ, real-time and label-free quantitative and qualitative characterization of adhesion and adhesives, such as surface plasmon resonance, spectroscopic ellipsometry, infrared, and Raman imaging.

Specific requirements and possibilities for bioadhesion applications will be discussed, with relevant biological examples.

Faimali Marco Italia

Academic Istituto di Scienze Marine – CNR

marco.faimali@ismar.cnr.it

The Institute of Marine Sciences (ISMAR, http://www.ismar.cnr.it/) is one of the 107 institutes of Italian National Research Council (CNR); it is composed of seven Research Units (Genova, La Spezia, Bologna, Trieste, Venezia, Lesina, Ancona) with its head office in Venice. ISMAR carries out multidisciplinary research in the fields of: physical oceanography, chemistry, biology and biogeochemistry, marine geology, coastal and lagoon geology, marine biology and fisheries technology, marine technologies and marine ecotoxicology.

Marco Faimali is responsible for the ISMAR units of Genoa, whose research activity is organized into the following sections: Materials corrosion and protections in marine environment; Biofouling and antifouling; Technologies for the environmental impact analysis. ISMAR Genoa group has a strong and well established experience in:

Laboratories for ecotoxicological studies, stereomicroscopes, SEM- and fluorescent microscopes, marine invertebrates breeding (algae, barnacles, sea urchins, echinoderms) and marine invertebrates (rotifers, brine shrimps). The Institute owns a marine station (Genoa Experimental Marine Station - GEMS, http://www.ismar.cnr.it/infrastructures/experimental-stations/experimental-marine-station-of-genoa/index_html?set_language=en&cl=en) fully equipped for mesocosms studies, exposure screening of materials in the marine environment (raft-test) and biosensors testing for biofilm monitoring.

After a lifetime of studying the methods and technologies to prevent settlement of biofouling organisms, the new adventure in to the COST Action dedicated to study the mechanisms of adhesion, seems extremely stimulating and our group will make available all its experience in the antifouling and ecotoxicology sectors.

Fardim **Pedro** **Belgium**

Academic KU Leuven

pedro.fardim@kuleuven.be

Polysaccharides show various naturally occurring nanostructures that can be isolated from biomass and converted to multifunctional biopolymers and tailored bioshapes for advanced applications in health care and wellbeing.

Polysaccharides are a common denominator for combining chemical engineering, chemistry, material science, bioscience and medicine to create a completely new generation of biomaterials, biomolecules, bionanohybrids and nutraceuticals.

In this work we present strategies based on the synergy of chemical engineering, interface chemistry and topochemistry to create a new interdisciplinary field of great relevance for industry and academic research and education.

Farkas **Robert** **Slovakia**

Academic Slovak Academy of Sciences

ueenfark@savba.sk

The salivary glue secretion (Sgs) of *Drosophila* is a mixture of 6 unique proteins which serves to affix the puparia to a substrate. The Sgs proteins comprise for 30% of the total protein content of the salivary glands. Smaller and inherently ordered Sgs proteins (Sgs-7 and Sgs-8) are either not glycosylated or considerably less glycosylated than the larger and structurally disordered Sgs proteins that are heavily glycosylated.

This identifies a specific paradox concerning the Sgs-proteins: the degree of order and disorder in the polypeptide chain is related to how much it is glycosylated. Ordered and disordered Sgs-proteins can serve to prevent an unwanted aggregation process within the densely packed secretory granules or even after exocytosis before the glue is programmed to solidify.

Drosophila Sgs proteins represents genetically tractable model to modify composition and identify structural motifs affecting adhesive properties.

Flammang **Patrick** **Belgium**

Academic University of Mons

Patrick.Flammang@umons.ac.be

The research works we are conducting within the Laboratory of Biology of Marine Organisms and Biomimetics at UMONS focus on the different protein-based adhesion mechanisms developed by marine invertebrates.

The aim of this research is to gain a precise understanding of adhesive processes, as well as a detailed knowledge of their role in the biology of the investigated organisms. The study centers on the tube feet and Cuvierian tubules of echinoderms but also on the adhesive organs of other groups such as tubeworms and sea squirts.

The different adhesive systems considered differ by their mode of operation, their structure and the characteristics of their adhesive proteins. They are therefore complementary biological models for the study of bioadhesion in the marine environment.

Whatever the model investigated, the study of the adhesion mechanisms is conducted from an integrated point of view, combining the results from different technical approaches to extract key structural, mechanical and chemical principles.

Fras Zemljic Lidija Slovenia

Academic University Mari

Lidija.fras@um.si

In this work, the surfaces of ultra-thin polydimethyl siloxane (PDMS) films were coated with chitosan (CT) and carboxymethyl chitosan (CMCT) nanoparticles (NPs) in order to introduce protein repellent properties to the PDMS films which otherwise exhibit unspecific protein adsorption, hindering its full potential in various biomedical applications.

The influence of CT and CMCT charge and adsorbed wet mass on their protein repellent properties, when coated on PDMS, were studied by means of QCM-D. The protein repellent studies have shown that the positively charged CS attracts the BSA and fibrinogen proteins rather than repels them, while the CMCT due to its zwitterionic nature improves the protein repellent properties of the ultra-thin PDMS films.

Furtos **Gabriel** **Romania**

Academic Raluca Ripan Institute of Research in Chemistr

gfurtos@yahoo.co.uk

Adhesion in dentistry is a important properties for developing new dental materials: dental adhesives, dental cements, dental seleants or dental composites. The mechanisms of adhesion to the enamel and dentin are employed by dental adhesives, which pursue either an etch-and-rinse or a self-etch strategy.

While micromechanical interlocking remains the primary adhesive mechanism, mild self-etch adhesives, in particular, may additionally make use of chemical interaction that especially contributes to the long-term stability of the bond.

Although one-step adhesives are the simplest to use clinical, their adhesive performance is less than that of multi-step adhesives, primarily due to lower bond strength and durability, phase-separation phenomena. Develop of new dental adhesives based on chemical reaction to human dentin and enamel is a priority in the restorative dental field.

Our interest is in the developing of new dental adhesives, dental cements, dental seleants or dental composites able to improve adhesion to human enamel and dentin.

Gorb **Stanislav** **Germany**

Academic University of Kiel

sgorb@zoologie.uni-kiel.de

Biological hairy attachment systems have robust adhesion and high reliability of contact. Meanwhile very convincing results have been achieved in manufacturing adhesive microstructures inspired by male chrysomelid beetles.

Comparative studies on microstructures with different contact geometries showed that beetle-inspired mushroom-shaped adhesive microstructure (MSAMS) even outperform the gecko-inspired spatula-shaped geometry.

Adhesion of MSAMS is reversible and even stronger under water. MSAMS can keep its adhesive capability over thousands of attachment cycles.

Additionally, the development of MSAMS provides an opportunity for biologists to run experiments, which would be otherwise only hardly possible with real biological system.

Haber **Meir** **Israel**

Company Biota Ltd

meir@algawish.com

Biota was founded in 1999 initially developing surgical adhesives and sealants utilizing novel algal bioadhesives.

Over the past fifteen years Biota developed patented and proprietary mucoadhesive filmstrips, based on alginates and other polymers that enable administration of pharmaceuticals and nutritional supplements directly to the bloodstream via the highly permeable oral mucosa membrane.

Upon administration, the mucoadhesive filmstrips adhere and reside at oral mucosa site of administration, e.g., sublingual, absorb saliva, swell and release the incorporated active ingredient, and eventually dissolve.

Transmucosal filmstrips address the need for improved pharmaceutical dosage forms that are non-invasive and simple-to-administer. Patient-friendly drug delivery systems are esepecially applicable for pediatric and geriatric populations, treatment of pain, and dosage forms for treatment of disabling diseases. Biota product portfolio include products for oral care, nutritional supplements, and medicinal cannabis.

Biota also provide R&D consultancy services in the field of surgical adhesives and sealants.

Hellio **Claire** **France**

Academic Université de Bretagne Occidentale

claire.hellio@univ-brest.fr

The growing demand to develop a novel, environmentally friendly antifouling or bioadhesive material is ever increasing. Bioinspiration is an attractive alternative in developing such a material, learning from nature's own designs and solutions and transferring them to solve particular problems. In order to achieve this goal, the actual mechanisms and strategies that evolution has produced needs to be elucidated from the subject species.

The work presented in this talk, regarding new antifouling product, has investigated successfully chemical ecology (macroalgae and sponges), the role of microflora in the production fo defense molecules, seasonality of the production of defences molecules, and defences synergy. The role of surface topography and chemistry combined in a single material, a property that exists naturally in some common macroalgae, has been as well investigated and led to promising results.

The second part of this talk will focus on bioadhesion strategies used by marine organisms and how from fundamental studies, we have develop a new bioassay for testing the activity of compounds in inhibition or promotion of algal adhesion.

Hennebert **Elise** **Belgium**

Academic University of Mons

elise.hennebert@umons.ac.be

My research group (laboratory of Cell Biology, UMONS, Belgium) is currently involved in a project in close collaboration with the laboratory of Biology of Marine Organisms and Biomimetics (Dr P. Flammang, UMONS, Belgium) in order to decipher sea star adhesion mechanisms.

These organisms rely on their tube feet to adhere to surfaces underwater by releasing a blend of adhesive proteins. Recently, transcriptome and proteome analyses were combined to obtain partial sequences for all adhesive proteins, the so-called sea star footprint proteins (Sfps). Moreover, the full-length sequence of Sfp1 was obtained. It consists of four subunits which display specific domains mediating interactions with other proteins present in the adhesive material and on the tube foot surface.

The project will aim at the identification and detailed characterization of additional Sfps and at the production and testing of recombinant proteins based on Sfps subunit.

Hiorth **Marianne** **Norway**

Academic University of Oslo

marianne.hiorth@farmasi.uio.no

Even though there has been a great improvement of the global oral health problems still remain in many communities. In US caries is increasing among the youngest part of the population and also the increasing amount of elderly in the population with dry mouth leads to poorer dental health.

In this study, different types of nanoparticles i.e. polysaccharide based nano-spheres and polysaccharide coated liposomes with the potential of mimicking the action of the micelle-like structures of saliva were developed. The particles adhesion to hydroxyapatite, a model substance of the teeth, the stability in artificial saliva and the cytotoxicity towards a buccal cell-line were investigated.

The study showed that the stability in artificial saliva and the bioadhesive properties were mainly dependent on the charge of the particles but were also related to the different types of materials used. The particles seem to have high potential.

Kamperman **Marleen** **Netherlands**

Academic Wageningen University

marleen.kamperman@wur.nl

Bio-inspired Functional Polymers

Nature has developed elegant and economical strategies to produce materials with exquisite structure control to accomplish specific properties. The use of these concepts to synthesize and/or process materials (biomimetics) is a rapidly emerging area of materials science.

In my research, I combine my experience in polymer synthesis, structure formation and patterning with my knowledge on bioadhesives. I aim to utilize biologically inspired strategies to develop materials for next generation adhesives and functional materials.

Katona **Jaroslav** **Serbia**

Academic Faculty of Technology Novi Sad

jkatona@uns.ac.rs

The colloid chemistry group offers broad theoretical knowledge and know how in the area of Colloid and Interface Science which has been accumulated during more than 50 years of existence, since the group foundation by Prof Lj. Djakovic in 1959. The group currently consists of two professors, 4 PhD students, 3 MSc students and 1 lab technician.

Research interest is directed towards investigation on rheological properties of complex colloidal systems, behavior of biopolymers in solution and biopolymer–surfactant interactions, emulsion and biopolymer based micro– and nanoencapsulation, and design of novel, all–natural functional colloids. The group has extensive hands–on experience in printing and coating formulation of functional materials, as well as in the dynamics of inkjet drop formation process. One of the current interests is focused on printed epidermal sensors, and in this regard issues of bioadhesion and transfer technologies for such sensors.

Available equipment within the group includes rheometer RS600HP from ThermoHaake, capillary viscometers from Canone, tensiometer Sigma 703D from KSV, min spray dryer Buchi 190, various homogenizers (microfluidizer M–5000, Ultraturrax T-25, Owerhead stirrer RW20, ultrasonic processor), Langmuir through, conductometer, optical microscopy, and many more available at the university campus (Zetasizer, Mastersizer, SEM etc).

Kizilel **Seda** **Turkey**

Academic Koç University

skizilel@ku.edu.tr

Seda Kızılel received her BS and MS degrees from Chemical Engineering, Boğaziçi University, and PhD degree from Illinois Institute of Technology, USA. She completed her postdoctoral work at the University of Chicago, and joined Koc University in Istanbul, Turkey, as a faculty in Chemical and Biological Engineering program in January 2008.

She was awarded with "Charles Huggins Most Outstanding Research" in 2006 at the University of Chicago, and Loreal Young Women in Science Award in 2009. She is currenty working as an Associate Professor in Chemical and Biological Engineering department at Koc University.

Dr. Kizilel's research efforts are directed towards development of novel bioengineering strategies for biomedical applications such as immunoisolation of insulin secreting islets within functional hydrogels for the treatment of diabetes with cell transplantation and development of nanoparticle and gel based composite materials for targeted drug or molecule delivery into cancer or tumor cells.

Kojic **Zeljka** **Bosnia and Herzegovina**

Academic University of Banja Luka

zeljka.kojic@yahoo.com

My name is Željka Kojić, and I work as Higher Assistant on Department of Periodontology and Oral Medicine, Medical faculty, University of Banja Luka, B&H.

My colleague Olivera Dolic and I work on research in field of herpes virus infections.

Our research is based on clinically treating efflorescence incurred recurrent herpes infection using reactive protein fibrin from venous blood of the host.
We take biopsy material from the center of efflorescence on the lips and in the mouth of patients before and after the application reactive protein fibrin.
In the microbiology laboratory, the ELISA test determines cytokines therapeutic response.

Clinically we determine the time interval of healing the efflorescence. The aim of the research is that by using reactive protein fibrin reduces the time interval of vesicles, when people are carriers of the herpes simplex virus, but also to improve the quality of life of people with recurrent herpes infection.

Krystofiak **Tomasz** **Poland**

Academic Poznan University of Life Sciences

tomkrys@up.poznan.pl

In last year's hot-melt (HM) adhesives are commonly used in woodworking industry. They are characterized with various adhesion to different materials (e.g. wood, wood based panels, plastics).

The aim of this work was the estimation of the adhesion properties of HM adhesives (on the various polymer basis - APAO, EVA with and without fillers, PA, reactive). Measurement of the contact angle of the adhesive layers for the distilled water as wetting liquid acc. to the PN-EN 828 standard was carry out. Water was applied with the chromatographic syringe in the form of drops about the volume 3.5 ul (10 repeats).

On the basis of contact angle measurements and accordingly to the theoretical assumption of the theory of adhesion the values of the surface free energy and work of adhesion were calculated.

Laaksonen **Päivi** **Finland**

Academic Aalto University

paivi.laaksonen@aalto.fi

The main interests in our studies are tailored proteins as builidng blocks for nanocomposite structures and for surface modification. We study adhesive and mechanical properties of recombinant proteins on different lenght scales all the way from molecular level to macroscopic materials properties.

The main aim is to develop molecular designs to enable high performance materials.

Ladurner **Peter** **Austria**

Academic University of Innsbruck

peter.ladurner@uibk.ac.at

The flatworm *Macrostomum lignano* can attach and release several times within a second on any substrate in seawater.

We have identified adhesive proteins using transcriptomics, differential gene expression, Mass Spectrometry, In situ Hybridization screening, Lectin staining and pull-down, specific antibodies, light- and electron microscopy.

The flatworm duo-gland system consists of an adhesive-, and a releasing gland cell, and a modified epidermal cell, the anchor cell. Using a combination of the methods we were able to narrow down the number of adhesion- and release related genes to few candidates. We now have identified two key adhesive proteins which result in a non-adhesive phenotype upon RNAi knock-down.

We aim for understanding the fundamental mechanisms that mediate adhesion and release in flatworms with the goal to generate a flatworm-derived biomimetic glue.

Research supported by Austrian Science Fund FWF No. 25404

Mano **João** **Portugal**

Academic University of Aveiro

jmano@ua.pt

Mussel-inspired materials have been produced mainly by exploring the incorporation of catechol in the molecular structure, in order to prepare biomimetic hydrogels or coatings.

We present results involving the modification of polysaccharides, such as hyaluronic acid or chitosan, that could allow to develop new structures with interest in the biomedical field, including tissue engineering.

Examples are shown on the preparation of multilayer films exhibiting adhesive properties, or double-network gels with injectability and self-healing capability.

Marchesan Silvia Italy

Academic University of Trieste

smarchesan@units.it

Self-assembly of heterochiral tripeptides

Supramolecular chirality arising from the assembly of small molecules is a hot topic in the fields of recognition, biomaterials and functional materials. In particular, appropriate choice of amino acid chirality is emerging as a powerful tool to fine-tune the self-organization of peptides as short as three amino acids.

Tripeptides are attractive minimalist motifs to convey biological messages and/or form macroscopic soft matter, although their self-assembly is difficult to predict. Not only different nanomorphologies can be achieved from subtle peptide sequence variations, but also dramatic effects may arise from a single change in stereoconfiguration (i.e., leading or not to a hydrogel within seconds).

The resulting assemblies hold high potential as biomaterials, as shown by their performance in vitro. This approach opens a number of interesting avenues towards bioadhesive materials.

Martin Martinez **Jose Miguel** **Spain**

Academic University of Alicante-Adhesion and Adhesives Laboratory

jm.martin@ua.es

Adhesion is a key issue in the design of medical devices. The mismatch of the surface properties of the substrate surface and the adhesive chemistry is essential for reaching an adequate performance.

Several examples developed at the Adhesion and Adhesives Laboratory will be shown dealing with ear prosthesis, medical patches and adhesives for wound closure.

McElhatton **Anna** **Malta**

Academic University of Malta

anna.mcelhatton@um.edu.mt

This department is one of the thirteen departments within the faculty of Health Sciences. It is a relatively young Department, only six years old that is responsible for training nutritionists, dietitians and Environmental Health Practitioners.

As a consequence together with the Nutritional Sciences we also have a strong Microbiology component and interest that stems from the need to investigate issues in food safety and quality.

Biofilms are an issue of concern to those interested in the food (including food contact materials) and dental environment. For this reason the Department is in the process of gearing up for research in this area.

Some research with biofilms on produce has already been initiated, we aim to focus on surface factors that lead to biofilm formation as we consolidate our infrastructure and network.

Nürnberger Sylvia Austria

Academic Medical University of Vienna

sylvia.nuernberger@meduniwien.ac.at

Bonding strategies are important for medical care and required to glue tissues, stabilize implants or close bleeding wounds (hemostasis). However, currently available medical gules are either harmful to the surrounding tissue (BioGlue®) or have a weak bonding strength (fibrin glue). For other fields of applications such as screws, there is no alternative glue-based method available.

At the Medical University of Vienna we are interested in basic research of potential biological adhesives as well as cell biological feasibility testing of prototype materials.

Our basic research focuses on the secretions of ticks which plug themselves into host skin by a sticky material. Further, we were involved in biocompatibility testing of secretions of various vertebrates and invertebrates.

Testing of new glue prototypes generally starts with *in vitro* cytocompatibility studies followed by *in vitro* tests of immune response and finally *in vivo* studies.

Pavan **Giovanni M.** **Switzerland**

Academic University of Applied Science of Southern Switzerland

giovanni.pavan@supsi.ch

The Department of Innovative Technologies (DTI) at SUPSI has a strong background in the use of computer simulation techniques for diverse technological applications – *e.g.*, biomaterials, polymers, composite materials, sensors, energetics, etc.

Dr. Giovanni M. Pavan is expert in multiscale molecular modelling and computer simulation. Research interests in the Pavan's group include bioinspired materials, adaptive/stimuli responsive materials, self-assembly, complex multivalent interactions (adhesion) and molecular glue. Molecular modelling offers tremendous advantages in the study of complex molecular interactions, and a useful tool at disposal of this COST action to rationally design new adhesives with controllable bioinspired properties.

Since 2010, Dr. Pavan published more than 50 research papers in high-impact peer reviewed journals (http://www.dti.supsi.ch/~pavan/publications.html). The Pavan's group owns fourteen dedicated high-performance simulation GPU stations equipped with state of the art hardware and software for molecular simulations, and has access to the hybrid GPU/CPU calculation cluster of DTI-SUPSI.

Pepelnjak **Tomaž** **Slovenia**

Academic University of Ljubljana

jm.martin@ua.es

Implementation of nature-imitated concepts in forming applications: Forming applications are widely used in industrial practice. In some cases bionic and bio-mimetic concepts are already implemented in order to enable better sliding of surfaces, material properties etc.

In the paper the forming processes will be presented in general with further focus to bio-imitated concepts. Finally, possible applications for implementation of bio-adhesive concepts and/or materials in research area and industrial applications will be discussed.

Power **Anne Marie** **Ireland**

Academic National University of Ireland, Galway

annemarie.power@nuigalway.ie

Stalked barnacle *Lepas anatifera* produces large quantities of adhesive proteins to permanently attach to various materials underwater but the adhesion mechanism is not fully understood.

RNA was extracted from ‘Glue Gland’ (n=4) and ‘Foot’ (n=3) and RNA seq transcriptome analyses were conducted using Illumina Hi-Seq 2000, with sequencing by synthesis conducted to generate 100 bp paired end reads. Real time (RT-PCR) was used to detect expression levels of candidate genes.

De novo assembly of the *L. anatifera* cDNA libraries generated a transcriptome of approximately 300,000 genes. 8,410 Differentially Expressed Genes (DEGs) were significantly up-regulated in Glue gland tissues ($p < 0.05$).

Homology between contigs upregulated in the Glue gland with published barnacle adhesive genes included cement protein (cp)-19k, cp-100 kDa and cp-114 kDa.

Reis **Catarina** **Portugal**

Academic — Universidade Lusófona de Humanidades e Tecnologias (ULHT) / Escola de Ciências e Tecnologias da Saúde (ECTS)

catarinapintoreis@gmail.com

The emergence of micro- and nanoencapsulation techniques together with the implementation of non-invasive and painless administration routes has revolutionized the pharmaceutical market and the treatment of several diseases.

In addition, to achieve an efficient drug administration, the development of biomaterials for drug delivery systems has been refined to fit specific applications. In this case, bioadhesive drug delivery systems interact with the mucus layer covering the mucosal epithelial surface, and mucin molecules and increase the residence time of the dosage form at the target site of absorption.

Thus, drug absorption by mucosal cells may be strongly enhanced or in another cases the drug may be released at the site for an extended period of time. This study describes the preparation of different polymeric nanocarriers and its characterization in terms of size, morphology, surface charge and adhesion properties.

Rothbächer **Ute** **Austria**

Academic University of Innsbruck

ute.rothbaecher@uibk.ac.at

Ascidians are tunicates and constitute major marine biofoulers. Ascidian larvae develop adhesive properties at the time of settlement to metamorphose to the filter feeding adult that finally adheres stably to the surface.

The ascidian *Ciona intestinalis* is also an important model organism for developmental genetics due to its invariable cellular lineage, a highly accessible genome and well established experimental resources. We take advantage of our knowledge of *Ciona* to study its adhesive properties.

We use high resolution microscopy for a detailed description of the glue producing cells and their specific vesicular contents. By differential transcriptomics and proteomics we have narrowed down a small group of candidate genes possibly contributing to ascidian glue formation.

We now analyse in detail the expression and function, in vitro and in vivo, of the adhesive candidates in light of biomimetic glues or anti-fouling reagents.

Saha **Nabanita** **Czech Republic**

Academic Tomas Bata University in Zlin

nabanitas@cps.utb.cz

Bacterial cellulose (BC) – a masterpiece of nature's arts, produced by bacteria in the natural environment as well as under controlled environment.
Hence, attempt will be taken for the production of BC using apple juice/ tomato juice/ diary waste etc. which are resourceful and inexpensive nutrient medium.

BC could be directly applicable as wound dressing biomaterial (burn wound/cut wound), bone tissue engineering/drug delivery etc. BC promotes thromogenecity in contact with blood as well.

Hence, effort will be given to identify the optimum bioadhesion condition which will be suitable for BC and BC based composites and explore their applications. Detail structural, functional and bioadhesive properties of BC will be discussed during presentation.

Saha **Nibedita** **Czech Republic**

Academic Tomas Bata University in Zlin

nibedita@uni.utb.cz

Nature-based solutions like bacterial cellulose (BC) have a large, but mostly untapped potential for contributing to bio adhesion. This paper is envisioned and highlight the importance of Multi-Stakeholder Initiatives (MSIs: science, policy, business, society, including SMEs, public and private investors) on BC production and its application for promoting innovative, multi-revealing, effective capability and commercially exploitable BC and BC based biocomposites.

Finally, it is assumed that MSIs would builds a multi-level (local, regional, national and EU) innovation platform to meet the societal challenges of Horizon 2020.

We tried to demonstrate the significance of building European Knowledge Based Bio-Economy (KBBE) innovative platform to exploit new and emerging research opportunities on BC and BC based biocomposites that address social, environmental, economic challenges and committed innovation partnerships; identify how different firms, people, and knowledge at national and international making civil society organizations (CSOs), non-governmental organizations (NGOs), individuals and institutions more innovative and competitive.

Santos **Romana** **Portugal**

Academic MARE - Marine and Environmental Sciences Centre

romana.santos@campus.ul.pt

I have 16 years experience on sea urchin adhesives and their adhesive organs, using a combination of morphological, biomechanical, biochemical and molecular techniques.

It was long believed that these animals used their adhesive organs as suckers to move and anchor to rocks. However, now we know that they produce adhesive and de-adhesive secretions, to attach and detach repeatedly from the substrate, using a reversible adhesive.

Sea urchin adhesive is water-resistant and effective on diverse substrata. Thus, it may find applications as a surgical adhesive or a tissue/cell-immobilising agent, while the de-adhesive secretion can be used to develop a reversible adhesive or a coating to prevent unwanted adhesion of proteins/cells to biomedical devices.

My recent research disclosed the key players in sea urchin reversible adhesion driving my focus to producing recombinant sea urchin-inspired adhesive proteins in view of a biomedical use.

Sedliacik **Jan** **Slovakia**

Academic Technical University in Zvolen

sedliacik@tuzvo.sk

Since 1995 till today, the pedagogical and research employer at Technical University in Zvolen, Faculty of Wood Sciences and Technology, Slovakia. The branch of interest is „Processing of Wood Technology“ with specialisation Adhesives and technology of gluing in woodworking industry.

The institution departments have built laboratories for determination of physical and mechanical properties of wood-based materials, laboratories of adhesives and plastics, surface finishing, and machining of wood. Laboratories are equipped with: AFM Multimode 8, SEM, gas chromatograph, liquid chromatograph HPLC Agilent Technologies, FTIR Nicolet iS10, ARAMIS 3D deformations, laboratory press, XENOTEST Q-SUN XE-3-HS, testing equipment LaborTech 5 kN head, etc.

The going research is aimed on lowering of formaldehyde emission from wood based panels by environmental progressive modification of polycondensation adhesives with biopolymers from leather waste, natural nanofillers, additives and activators. These components determine new parameters of the adhesive mixtures and bonded composite materials on theoretical and industrially applicable level.

Sionkowska **Alina** **Poland**

Academic Nicolaus Copernicus University in Torun

as@chem.umk.pl

The aim of this work was to prepare collagen/chitosan thin film with silver nanoparticles for potential biomedical applications. Thin biopolimeric film were obtained by solvent evaporation from collagen/chitosan mixture.

Obtained films were analyzed using FTIR spectroscopy. Mechanical properties of film were tested in dry condition using mechanical testing machine. Microstructure of films was analyzed by Scanning Electron Microscope and Atomic Force Microscope.

Moreover, water stability was studied by measurement of swelling in 37°C in body-like fluid. The surface properties were analyzed by contact angle measurements using hydrophilic and hydrophobic liquids.

Moreover, antimicrobial properties of collagen/chitosan/silver composites were tested during microbiological test.

Sosnik **Alejandro** **Israel**

Academic Technion – Israel Institute of Technology

alesosnik@gmail.com

Poor aqueous solubility of drugs is one of the most challenging drawbacks in pharmaceutical product development. Different nanotechnology platforms have been developed to improve the biological performance of those drugs.

Polymeric micelles (PMs), nanostructures generated by the spontaneous arrangement of amphiphilic copolymers blocks above the critical micellar concentration, have emerged as one of the most versatile ones owing the high diversity of hydrophilic and hydrophobic blocks and the chemical flexibility to tailor the amphiphilic structure.

PMs were mainly utilized for the intravenous administration of antitumorals drugs and not for mucosal routes because of weak interaction with mucus and inability to sustain the release of the encapsulated payload over time.

I will present our most recent results on the synthesis of mucoadhesive polymeric micelles.

Tho **Ingunn** **Norway**

Academic University of Oslo

ingunn.tho@farmasi.uio.no

My main research area is the development of new bioadhesive (mucoadhesive) drug delivery systems. We are targeting the mucosal tissue in the oral cavity, buccal mucosa, as well as the vaginal mucosa, with respect to improved local therapy as well as systemic absorption.

A main challenge at both sites is the short residence time of the drug delivery system due to constant secretion of fluids, saliva in the oral cavity and cervical fluids in the vaginal tract.

Bioadhesion is a mean to increase the residence time on the site of action, and is therefore one of our focus areas.

Toksoy Oner **Ebru** **Turkey**

Academic Marmara University

ebru.toksoy@marmara.edu.tr

Levan is a natural polysaccharide that is microbially produced by diverse microorganisms from sucrose. It is composed of fructose monomers that are linked by beta (2-6) linkages.

Levan has a big potential for being a biomaterial with its outstanding properties such as solubility in oil and water, strong adhesivity, high biocompatibility and film-forming ability.

In this talk, after introducing Levan polysaccharide as a bioadhesive material, recent research activities of our IBSB research group will be presented in detail.

Vlassov Sergei Estonia

Academic University of Tartu

vlassovs@ut.ee

In recent decades, a lot of effort was put into the investigation of friction and adhesion on the fundamental level. Most common tool used for studying of nanoscale adhesion and friction is atomic force microscope (AFM).

It provides high resolution and accuracy, however it has certain limitations. Main problem is that manipulation and visualization cannot be performed simultaneously.

In our work, we use real-time manipulation technique inside a scanning electron microscope (SEM) employed for tribomechanical characterization of nanostructures. Strong advantages of the AFM are combined with visual guidance of the SEM.

In my talk, different approaches to friction force measurements are described through the examples on various nanowires and nanoparticles of different geometry. Limitations of the method are discussed.

Von Byern **Janek** **Austria**

Academic Ludwig Boltzmann Institute for Experimental and Clinical Traumatology

vbyern@freenet.de

The LBI for Experimental and Clinical Traumatology hosts state-of-the-art facilities for intensive care and regenerative medicine. With its full translational approach and an interdisciplinary team including trauma surgeons veterinarians, life scientists in particular molecular biologists, engineers, etc. it provides an optimal research environment with the special research areas of tissue regeneration (bone, cartilage, soft tissue/wound healing, neuro trauma). Furthermore it provides the necessary preclinical animal models for bone repair, required for the proposed project.

Janek von Byern focus his research on adhesive systems in marine and terrestrial animals for which he has received both national and international funding. Due to his research Dr. von Byern is familiar with morphological techniques, molecular biology, biomechanics and biochemical methods and characterizes the biocompatibility of bioadhesives through cell culture and bacteria tests.

Vrabic Brodnjak Urska Slovenia

Academic University of Ljubljana

urska.vrabic@ntf.uni-lj.si

Research area: bio polymers used in paper and packaging industry. Coatings or fillers as additives in and on paper, cardboards and boards. Films for packaging made from chitin, chitosan, starches (rice, potato), soya bean proteins and curdlan.

Research important for the ENBA: Research important for this COST action will be investigating chitin, chitosan, starches (and other suitable bio polymers) as a potential and effective adhesives-natural binders for paper and packaging industry. It will be the most important to evaluate their bonding properties in macro-, micro- and nano-scale and after that to use them in real environment/industry.

Equipment: instruments for paper and packaging analysis such as: tensile testing machine, instruments for analysis such as DMA, FTIR, SEM, bursting strength, smoothness, air permeability, porosity, water retention, rubbing permeability, climate chambers etc. Printing machines and techniques for offset, digital, screen, pad and 3D printing.

Werner **Dalal** **France**

Company Aérial

da.werner@aerial-crt.com

Biofilm is defined as a community of microorganisms sticking together and forming a cluster. Biofilm forms when bacteria adhere to surfaces and begin to excrete adhesive and protective exopolysaccharides. These latter synthesized vary greatly in their composition and hence in their chemical and physical properties. Biofilm development kinetics is closely linked to the environmental conditions (temperature, humidity) as well as material surface properties.

The work presented here concerns the optimization and the implementation of a microbiological method for monitoring the formation and growth of biofilm under ageing conditions and with regard material surface properties.

Microbiology is also a concern when it comes to sterilization of medical devices such as bioadhesives. Irradiation with Gamma or electron beams is the most common technique used to sterilize biomaterials, pharmaceuticals and medical devices. Microbicidal effect of irradiation is not longer to proof. However, this sterilization process may have a negative impact on the physical, chemical and mechanical properties of biomaterials.

Our purpose here, aims to give an overview on the potential effects of irradiation on the mechanical and physical properties of radiation sterilized bioadhesive.

Zurovec **Michal** **Czech Republic**

Academic Biology Centre CAS

zurovec@entu.cas.cz

The silks produced by *Lepidopteran* larvae consist of fibroin proteins forming two core filaments, and sericin proteins that seal filaments into the cocoon.

We studied silk composition in three moths, *Bombyx mori*, *Antherea yamamai* and *Galleria mellonella* and found that each of them contains at least three divergent sericin genes. Different sericins are expressed by different parts of silk glands at different times.

Our results revealed that sericins greatly influence silk properties. We also showed that the highly adhesive *Bombyx* sericin 2 contains repetitive sequence exhibiting a remarkable similarity with the adhesive protein from blue mussels.

To get more information on sericins in other lepidopteran species we use de novo transcriptome sequencing and proteomic analysis of silk proteins. We prepare a database of cDNA sequences, which will provide information for clarifying structural-mechanical rules that control the stickiness.

Abstracts Participants

Badalamenti **Fabio** **Italy**

Academic Institute for the Coastal and Marine Environment

fabio.badalamenti@cnr.it

Substrate roughness affects the strength of root hairs adhesion on *Posidonia oceanica* seedlings

Posidonia oceanica, the dominant Mediterranean seagrass, has been historically described as a species typically growing on mobile substrates whose development requires precursor communities.

However, recent studies have described adhesive root hairs for seedlings of this plant that insure a strong anchorage, up to 24N, to consolidate substrata.

Here we report on further and detailed information on the root hairs mechanism adhesion on substrate with different degrees of roughness.

Barnes **Jon** **United Kingdom**

Academic University of Glasgow

Jon.Barnes@glasgow.ac.uk

Dynamics of adhesion in tree frogs

Tree frogs possess smooth adhesive toe pads that adhere by wet adhesion, involving both capillarity and viscosity-dependent hydrodynamic forces. They are made up of polygonal, flat-topped cells, surrounded by channels. Mucous glands produce a watery fluid that spreads over the pad through these channels. The surface of the cells is densely covered by nanopillars, which are thought to generate high friction forces, possibly by direct contact with the substrate.

Here we show for the first time, using interference reflection microscopy on the pads of living adhering frogs, *Phyllomedusa trinitatis,* how adhesive pads are used by the animal as the need for adhesion and friction progressively increases. As the microscope (on which the frog sits) is progressively tilted from the horizontal (0°) towards the vertical (90°), pad/ground distances decrease, until large areas of the pads are within a few nm of the surface. This will lead to increased friction, particularly if the tips of the nanopillars come into direct contact with the substrate, while the substantial decrease in the thickness of the fluid layer will increase the hydrodynamic component of adhesion.

In this short talk, I will describe the above experiments and their effects on the friction and adhesion forces which prevent both sliding and falling in most cases. I will also discuss unresolved problems, including the fate of the displaced fluid and what forces might cause the pad to be pushed against the surface in the first place.

Baudis **Stefan** **Austria**

Academic Technical University Wien

stefan.baudis@tuwien.ac.at

The Institute of Applied Synthetic Chemistry (IAS) is divided in three divisions comprising the full range from inorganic and organic molecular and surface chemistry and macromolecular chemistry (MC).

The Institute is equipped with state-of-the-art instrumentation for preparation and characterization of low molecular mass and macromolecular substances. Furthermore, special equipment for photoexperiments is available, including Photo-DSC, Photo-Rheometry, Photo-RT-FTIR.

The Division Macromolecular Chemistry works more than 20 years in the area of photoinitiated polymerization reactions and renewable resources. The research projects focus on the development of photoinitiators and monomers for light based 3D printing and the exploitation of sustainable macromolecular systems for industrial applications.

The primary competences are synthesis of monomers and photoinitiators, preparative polymer chemistry including polymer characterization, modification of (bio)polymers, biocompatible polymers, and functional polymers. Based on the developments on efficient and environmentally friendly components several cooperations with the industry were founded already leading to products that hit the market recently.

Bekhta **Pavlo** **Ukraine**

Academic Ukrainian National Forestry University

bekhta@ukr.net

Website: http://tdkm.nltu.edu.ua/kolektyv/bekhta.php (Ukrainian language only) and http://tdkm.nltu.edu.ua (Department of Wood-Based Composites, Celulose and Paper, Ukrainian language only)

Research interest

Development of innovative wood-based composites, composites made of agricultural wastes and recycled waste materials, surface modification

Specialized technique available in my lab

Lab equipment for

- the preparation of wood-based composites (e.g. plywood, particleboard)
- the preparation and impregnation of wood
- instrument for colour measurement

Additional comment

The Department of Wood-Based Composites, Cellulose and Paper research team focuses its research on the development of eco-friendly products and processes (e.g. bonding technologies, flat pressed wood-polymer composites, fire-resistant plywood, plywood using veneer of high moisture content, wood-straw particleboard). It is also specialized in the modelling and simulation of colour changes of wood surfaces.

Bennemann **Michael** **Germany**

Academic Westphalian Institute for Biomimicry

michael.bennemann@w-hs.de

Biomimetic adhesion devices along the lines of the adhesive organs of stick insects

In this study the detailed structures of the adhesive organs of the stick insect Carausius morosus were analysed and, based on the obtained data, artificial adhesion devices were constructed and finally validated. The morphological results led to four different designs for the fabrication of artificial adhesion devices.

Among the four biomimetic adhesion devices, the one with flock fibres showed the highest adhesion force of about 1.25 N/cm², a value slightly higher than the adhesion force of stick insects without the contribution of friction. This high adhesion force seems to be based on the reinforcement of the adhesion device with fibres, by which pulling forces are uniformly transferred to the contact area of the adhesion device to the substrate.

A non-uniform loading of the contact area easily leads to a local detachment at the area of the highest loading, which could lead to a gradual detachment of the whole adhesion device.

Bonneel **Marie** **Belgium**

Academic Research Institute for Biosciences

marie.bonneel@student.umons.ac.be

Adhesion of sea cucumber Cuvierian tubules: Identification and characterization of adhesive proteins

Cuvierian tubules form a specialized defense system occurring in some species of sea cucumbers. These long sticky tubules are able to entangle potential predators in a matter of seconds.

As for other bioadhesion systems, their adhesive consists mostly of proteins. Cuvierian tubules, however, stand apart because of their instantaneous adhesion without the necessity for curing.

We identified the proteins in the glue of *Holothuria forskali* by mass spectrometry combined to transcriptomic analyses. This approach allowed to establish a list of 41 candidates. To validate the adhesive function of these proteins, their expression in the adhesive epithelium of the tubule has been confirmed by in situ hybridization and immunohistochemistry.

The next steps will be the identification of post-translational modifications with a special emphasis on phosphorylation, and the extraction of adhesive protein precursors directly from the adhesive cells.

Clare **Anthony** **United Kingdom**

Academic Newcastle University

tony.clare@ncl.ac.uk

Tony is Professor of Marine Science at the Newcastle University and Fellow of the Institute of Marine Engineering, Science & Technology. He gained his PhD from Bangor University in 1984. His first faculty appointment was at Duke University in 1990, where he continued his research on barnacle biology and embarked on research in the field of marine antifouling sponsored by the US Office of Naval Research.

Tony returned to the UK in 1993 for a Fellowship at the Marine Biological Association (MBA) of the UK where he focussed on invertebrate larval settlement behaviour funded mainly by the Natural Environment Research Council. While at the MBA he was Scientific Co-ordinator for the UK's Marine Biofouling Thematic Programme. Tony transferred to Newcastle University in 1999 and was awarded a Personal Chair in 2003. His research group focuses on marine organism-surface interactions; predominantly factors modulating behaviour and adhesion of fouling organisms such as barnacles, tubeworms and algae.

Tony has served on numerous national and international scientific and technical panels. He has convened several international conferences, most recently the 15th International Congress on Marine Corrosion and Fouling in 2010. His professional duties include: Chair of the Comité International Permanent pour la Recherche sur la Préservation des Matériaux en Milieu Marin; Executive Board Member of the National Oceanography Centre Association and EC SEAFRONT; and Editor-in-Chief of the Journal of Marine Science and Engineering.

Conlan **Sheelagh** **Ireland**

Academic Liverpool John Moores University

S.L.Conlan@ljmu.ac.uk

The impact of temperature, feed rate and flow on growth and adhesive production in *Balanus amphitrite*

Balanus amphitrite is used for fouling release (FR) surface testing and grown under different temperatures, flow rates and feeding rates. The effect of these factors on adhesive production is understudied.

Here the growth and adhesive ring formation of *B.amphitrite* at different temperatures, feeding regimes and flow rates are examined. Cyprids were settled and then grown to adult at set temperatures, feeding or flow rates. Adults were then removed from their substratum and rings of adhesive stained. The number of rings, area of cover and width of bands was evaluated. Basis coverage with adhesive increased both with increasing temperature and food availability.

Barnacles grown on an inferior FR coating showed a strong negative correlation of adhesion strength to temperature. When grown in flow barnacles grew more slowly. While there was no difference in the width of adhesive bands there was a difference in the space between bands.

Cyran Norbert Austria

Academic University of Vienna

norbert.cyran@univie.ac.at

The Core Facility Cell Imaging and Ultrastructure of the University of Vienna is unique in supporting "in house" teaching and research experience in zoology in the field of cell biology, comparative morphology, molecular biology and glandular morphology. Methodological training includes histology, scanning and transmission electron microscopy, morphometrics and molecular biology as well as cryo preparation of samples for electron microscope. For details see http://cius.univie.ac.at/

Norbert Cyran focuses his research within the last years on the gland morphology of adhesive but also hatching gland systems in marine and terrestrial animals. Due to his research Mag. Cyran is familiar with morphological techniques as light, electron and confocal laser scanning microscopy, microCT and computerised 3D animated reconstruction.

Dobeš **Pavel** **Czech Republic**

Academic Masaryk University

pavel.dobes.sci@gmail.com

Insect physiology and immunology

Our primary focus is on mechanisms of host-pathogen interaction and biological effect of factors produced by insects and pathogens during infection (such as lectins and proteases produced by nematobacterial pathogens).

In our work we use insect model species like *Bombyx mori*, *Galleria mellonella*, *Apis mellifera* and *Drosophila melanogaster* which might be of interest for COST community.

Methodological approach is based on molecular biology and biochemistry techniques employed in genetically modified insect models and beneficial species.

Dorrer Victoria Austria

Academic Technical University Wien

victoria.dorrer@gmail.com

The TU Wien (Vienna University of Technology) has strength in combining international research and research from economics and public funding. The Institute of Chemical Technologies and Analytics (CTA) is part of the Faculty of Technical Chemistry. The Analytical Instrumentation Center (AIC) is part of the institute and runs the latest instrumentation for high-end Analytical Chemistry. It bridges different research areas in (Bio-)Chemistry and Technology and unifies basic with applied sciences & technologies. The Omics-Technologies research group, headed by Martina Marchetti-Deschmann, is focussing on high-end instrumentation and method development in Life Sciences (medicine, biotechnology, biomedical engineering, sustainability, …). The research focus for this group is mass spectrometry, including mass spectrometry imaging, and sophisticated separation techniques that are are combined with various imaging technologies.

Victoria Dorrer is a master student working on the biological adhesive of *Arachnocampa luminosa*, by using different mass spectrometric applications, gas chromatography and gel-electrophoresis. The results of this work are presented, in a poster ("*Arachnocampa luminosa*: Bio-adhesive investigation") within this meeting.

Dworak **Claudia** **Austria**

Academic Technical University Wien

Claudia.dworak@tuwien.ac.at

The Institute of Applied Synthetic Chemistry (IAS) is divided in three divisions comprising the full range from inorganic and organic molecular and surface chemistry and macromolecular chemistry (MC).

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Gorb **Elena** **Germany**

Academic Kiel University

egorb@zoologie.uni-kiel.de

Adhesion on the waxy zone in *Nepenthes alata* pitchers

Adhesion measurements were performed using sticky polydimethylsiloxane half-spheres as probes on two plant samples, bearing either intact two-layered wax or one-layered wax, and two control epoxy resin surfaces.

The lowest adhesion was detected on the intact plant sample. The microrough control showed the highest adhesion. Forces measured on the smooth control and one-layered wax ranged between those of other samples. SEM observations revealed that only the intact plant sample contaminated the probes. The force reduction on the intact plant surface may be explained by low real contact area due to the surface microroughness and contamination of the sticky probes by wax platelets.

The relatively high adhesion force detected on the one-layered wax sample may be caused by the low elasticity modulus of the used polydimethylsiloxane, resulting in its partially inflow into cavities between projections of the wax layer and thus, in an increase of real contact area.

Hyrsl **Pavel** **Czech Republic**

Academic Masaryk University

hyrsl@sci.muni.cz

Insect physiology and immunology

Our group study physiology and immune mechanisms of insects. Defensive responses can be triggered in insects subjected to stress conditions and also because of microbial invaders or parasitation.

We use model insects such as the silkworm (*Bombyx mori*), greater wax moth (*Galleria mellonella*), honey bee (*Apis mellifera*) and fruit fly (*Drosophila melanogaster*).

Recently we focus mostly on mutants and RNAi lines of genetically tractable insect - *D. melanogaster* where we study genes involved in the response to nematobacterial infection delivered by entomopathogenic nematodes. These nematodes are known to be very important for biological control of several insect pests.

In our experiments *Heterorhabditis bacteriophora*, *Steinernema feltiae* and *Steinernema glaseri* are used because these species differs in pathogenity and their recognition as non-self matter in insect hosts. We identified several insect genes and mechanisms important for early host defence against nematodes and their symbiotic bacteria.

Ivankovic Alojz Ireland

Academic University College Dublin

alojz.ivankovic@ucd.ie

UCD Centre of Adhesion and Adhesives

A.Ivankovic is Professor of Engineering Mechanics, Head of Mechanical Engineering Programs and director of UCD Centre of Adhesion and Adhesives.

He is also a Visiting Professor at Imperial College London and a Head of Structural Adhesives Division of Adhesion Society. AI currently leads the research group of 2 MSc, 7 PhDs, 3 PostDocs and 1 Senior Fellow.

The research focus of the group is the structure-property relationship towards materials by design, which involves multi-scale characterisation and modelling of thermo-mechanical, damage and fracture behaviour and tailor design of polymers, composites, adhesives and super-hard materials.

The group has access to excellent processing, thermo-mechanical testing, video, microscopy, analytical and high performance computing facilities. AI track record: 318 publications (95 journal, 5 book chapters, 218 conference); 25 graduated PhDs, 19 MSc, 14 PostDocs; Funding total over €9M;1 patent.

Kovacevic Davor Croatia

Academic University of Zagreb

davor.kovacevic@chem.pmf.hr

Influence of Polyelectrolyte Multilayer Properties on Bacterial Adhesion Capacity

Bacterial adhesion can be controlled by different material surface properties, such as e.g. surface charge. Therefore, we studied the adhesion of *Pseudomonas aeruginosa* on polyelectrolyte multilayers (PEMs) which are surface coatings that could be obtained by alternated deposition of positively and negatively charged polyelectrolytes on a solid surface.

We use a silica surface on which poly(allylamine hydrochloride)/sodium poly(4-styrenesulfonate) PEMs were formed. The surface charge was examined by the zeta-potential measurements and it was observed that ionic strength and polyelectrolyte concentrations significantly influenced the build-up process. The extent of adhered bacteria on the surface was determined by SEM.

The results showed that the extent of adhered bacteria mostly depends on the charge of terminating polyelectrolyte layer, since relatively low differences in surface roughness and hydrophobicity were obtained.

Langowski **Julian** **Netherlands**

Academic Wageningen University

julian.langowski@wur.nl

Secure and gentle grip to delicate biological tissues: Morphology, attachment and biomimetics of tree frogs' toe pads

Common abstract by Julian Langowski and Johan van Leeuwen

Tree frogs can hold to smooth and rough, dry and wet surfaces using their sticky toe pads. The study of the pads helps to understand the morphology and ecology of tree frogs, provides in-sights into the fundamental mechanisms of adhesion and friction in biology and facilitates the development of tree-frog-inspired, biomimetic adhesives.

Inspiration by the soft toe pads might be especially beneficial for the design of surgical grippers for wet, slippery tissues. A good understanding of the fundamental mechanisms of tree frog attachment is crucial for the successful design of a biomimetic gripper.

To answer the question, how tree frogs stick, we address this complex problem with experimental and numerical approaches as well as quantitative morphological analyses.

We carried out first experiments on the interaction of tree frogs' toe pads with substrates of different roughness and finite element simulations of the pad-substrate contact.

Lee **Haesin** **South Korea**

Academic Korea Advanced Institute of Science & Technology

haeshin@kaist.ac.kr

In materials science, catecholamines, the chemistry found in mussel adhesive proteins, have recently attracted significant attention due to the unprecedented material-independent surface-functionalization properties found in poly(dopamine) (H, Lee et al. *Science* 2007).

The material-independent coating properties are developed only when both catechol and amine moieties coexist in backbones. In contrast, when the both moieties are 'not' covalently linked, they exhibit self-sealing properties at liquid/air interfaces. The self-sealing requires only O_2 in air, and other external stimuli such as light, heat, and pH, as well as co- factors such as catalysts are not necessary. As self-sealing utilizes oxygen, regeneration of the catecholamine materials occurs unlimited times as long as the precursor solution exists, and more than 100 times of self-sealing was demonstrated.

Finally, this seminar will present a hemostatic needle which results in blood vessel self-sealing exhibiting no bleeding after needle injection and withdrawal (H. Lee et al. *Nature Materials* 2017).

Lefevre **Mathilde** **Belgium**

Academic University of Mons

mathilde.lefevre@umons.ac.be

Production and testing of recombinant sea star adhesive proteins

Sea stars are emblematic of the seashore. Despite this, their ability to attach strongly but temporarily to rocks underwater is poorly understood. Tube feet, the adhesive appendages of sea stars, release a blend of adhesive proteins, the so-called sea star footprint proteins (Sfps).

Recently, transcriptome and proteome analyses were combined to obtain the full-length sequence of Sfp1, a large protein which presents various domains distributed over four subunits. The molecular layout of Sfp1 provides a relatively unexplored design paradigm for engineering specific adhesion between different tissues for various applications in the biomedical field.

The aim of this project is to decipher the temporary adhesion mechanism developed by sea stars at the molecular level through the simplification of the system by the production and testing of recombinant proteins based on Sfp1 subunit or domain sequences.

Lengerer **Brigit** **Austria**

Academic University of Innsbruck

birgit.lengerer@uibk.ac.at

Adhesive organ regeneration in *Macrostomum lignano*

The adhesive organs of the marine flatworm *Macrostomum lignano* are a perfect system to study post-embryonal organ formation. One adhesive organ consists of solely three interacting cells, two secretory cells and one modified epidermal cell.

When amputated the organs regenerate completely within 9 days. Using cell type specific lectin- and antibody staining, as well as transmission electron microscopy, we analyzed the morphology of the adhesive organs during different regeneration stages.

Furthermore, we used RNAseq to characterize temporal expression levels in the regenerating tail plate of *M. lignano*. We compared this data with our previous posterior region specific *in situ* hybridization screen and identified novel organ-specific transcripts. We characterized adhesive organ- and prostate-specific transcripts that are expressed during the regeneration of the tail plate.

Our findings contribute to a better understanding of organogenesis in flatworms and enable further molecular investigations of cell-fate decisions during regeneration.

Marchetti-Deschmann **Martina** **Austria**

Academic Technical University Wien

martina.marchetti-deschmann@tuwien.ac.at

The TU Wien (Vienna University of Technology) has strength in combining international research and research from economics and public funding. The Institute of Chemical Technologies and Analytics (CTA) is part of the Faculty of Technical Chemistry. The Analytical Instrumentation Center (AIC) is part of the institute and runs the latest instrumentation for high-end Analytical Chemistry. It bridges different research areas in (Bio-)Chemistry and Technology and unifies basic with applied sciences & technologies. The Omics-Technologies research group as part of CTA is strongly involved in the development of new instrumentation, methodologies and analytical approaches for biomedical and biotechnological research.

Martina Marchetti-Deschmann is head of the Omics-Technologies group at CTA, TU Wien. Her research focus is high-end instrumentation and method development in Life Sciences (medicine, biotechnology, biomedical engineering, sustainability, …) with emphasis on mass spectrometry. Latest developments are mass spectrometry imaging for unbiased visualization of molecule distributions in (biological) material and matter.

Nitschke **Jonathan** **United Kingdom**

Academic University of Cambridge

jrn34@cam.ac.uk

Complex biomimetic adhesives containing cages

We are interested in generating new biomimetic hydrogels that are crosslinked through three-dimensional container molecules.

These materials could serve as stimuli-responsive adhesives, where a (bio)molecular stimulus could result in the release of guest molecules from cages, which could in turn engender a further cascade of events.

The incorporation of biocompatible cages into bioadhesive materials could also alter the adhesives' properties in useful ways.

Palomo **Jose M** **Spain**

Academic Institute of Catalysis (CSIC)

josempalomo@icp.csic.es

Site-specific biomolecules incorporation on protein surface

The development of chemoselective, site-specific chemistries for proteins is essential for biochemistry, pharmaceutical chemistry, medicine and biotechnology.

In particular the introduction of specific biomolecules such as peptides, polymers, carbohydrates, or other kind of cross-linking agents such as polyamines, polycarboxylic or polyols molecules have been excellent strategies for improving stability, solubility and biocompatibility of different types of proteins and enzymes.

Different kind of techniques for protein derivatization on aqueous solution based on synthetic organic chemistry such as chemical amination, maleimide cysteine conjugation, lysine modification or click ligation have been successful used for protein modification as well as physical interaction for modification or protein immobilization on polymeric surfaces.

These all strategies would be very useful for the creation of novel biological adhesives proteins.

Penk **Michael** **Germany**

Others Beilstein-Institut

mpenk@beilstein-institut.de

The Beilstein-Institut is a non-profit foundation based in Frankfurt am Main, Germany. In the focus of the foundation's work are projects to support communication in science.

These include the Beilstein Open Access Journals, which are also free for authors, and the video portal Beilstein TV with worldwide free access. The Beilstein-Institut organizes international symposia and coordinates data standardization projects.

A Thematic Series on biological and bioinspired adhesion was published in the Beilstein Journal of Nanotechnology and edited by Stanislav Gorb and Kerstin Koch. All articles can be downloaded from www.bjnano.org. This series inspired a Beilstein Nanotechnology Symposium in 2016 with the same topic, which was scientifically organized by Stanislav Gorb.

Scientific videos about functional biological materials such as snake skin or biological adhesives can be seen on www.beilstein.tv.

Penning **Manfred** **Germany**

Company PennConsult

mhp.shellac@t-online.de

Shellac is the refined form of lac, a resinous secretion of the tiny scale insects *Kerria lacca* in India. The chemical composition, colour and performance depend on the insect strain and the method used for refining.

Shellac refined by solvent extraction can be produced with high purity and uniform quality. Shellac can be applied from alcoholic or aqueous alkaline solutions. It has excellent film forming properties and a good adhesion to many surfaces, good surface hardness with high gloss, UV resistance and a good compatibility with other natural or synthetic polymers.

It has thermoplastic and, after crosslinking thermosetting properties. It is a food additive in Europe (E 904) and GRAS in the US and listed in the EurPharm and the USP. Applications in Food and Pharma are as barrier and enteric coatings of tablets or capsules and in micro encapsulation of solids and liquids.

In medicine technology, applications are in wound healing and the coating of stents. It is a unique natural, renewable and biodegradable polymer.

Pjeta **Robert** **Germany**

Academic University of Innsbruck

robert.pjeta@uibk.ac.at

Bioadhesion research on the Proseriate flatworm *Minona ileanae*

Many animals of the interstitial fauna have developed temporary adhesives that prevent them from being spilled away by water currents. Among flatworms, Proseriates are key species in beaches with high wave impact.

Living in such a high energy environment requires highly sophisticated temporary adhesives. Here, we present our findings on the bioadhesion of the Proseriate flatworm *Minona ileanae*.

By the use of transmission electron microscopy we were able to morphologically characterize the *Minona ileanae* duo-gland adhesive system. In order to identify adhesion candidate genes we performed a whole mount in situ hybridization screen.

We found eight transcripts that had expression in adhesion related tissue. A RNA interference knock-down experiment resulted in reduced adhesive performance for four transcripts.

In future investigations we aim to characterize and compare adhesion molecules on a molecular level of several flatworm species.

Poulsen **Nicole** **Germany**

Academic Technische Universität Dresden

poulsen@bcube-dresden.de

Trailins: a new protein family in the adhesive trails of diatoms

Diatoms and bacteria are the dominant taxa in marine biofilm communities that colonize every biotic or abiotic surface in sunlit marine environments. Underwater adhesion of diatoms is accomplished through the secretion of carbohydrate-rich extracellular polymeric substances (EPS). In motile pennate diatoms the adhesive EPS are secreted through a specialized slit in the cell wall (termed raphe) and are deposited as trails on the substratum thus providing the traction required for cell motility.

So far, the molecular composition of the diatom adhesive trails has remained poorly characterized. Recently, we have developed a method for isolating cell-free diatom adhesive trails, and demonstrated that they contain a complex mixture of carbohydrates and proteins.

Here we report our results from the proteomics analysis of adhesive trails that were isolated from the fouling diatom, *Amphora coffeaeformis*. The material contains a novel family of proteins, which we named trailins that exhibit rather diverse sequences in their N-terminal regions but share conserved C-terminal domains. Interestingly, each of the C-terminal domains includes a GDPH motif which also occurs some in other extracellular proteins (e.g. sea star foot protein and mucins) and is believed to be a pH triggered autocatalytic cleavage site required from intermolecular cross-linking.

Immunolocalization studies confirmed the presence of trailins within a previously unknown domain structure of the adhesive trails. This work provides the first insight into the biomacromolecular structure of diatom EPS trails and lays the foundation for unraveling the molecular mechanism for diatom biofouling.

Redl **Heinz** **Austria**

Academic — Ludwig Boltzmann Institute for Experimental and Clinical Traumatology

Office@trauma.lbg.ac.at

From Molecules to the Clinic - Austrian Cluster for Tissue Regeneration (ACTR)

The ACTR integrates facilities of the Ludwig Boltzmann Institute for Trauma (LBI Trauma) and 16 further research groups of 7 universities in Austria. The cluster offers state-of-the-art facilities for tissue engineering including (stem/endothelial) cell research.

With its fully translational approach, an interdisciplinary team including MD/VetMD, location partly in hospitals and a GMP facility it provides an optimal research environment. ACTR covers - Neuroregeneration, Soft Tissue Repair, Cartilage/Tendon and Bone/Ligament Regeneration as well as competence centers for molecular biology, miRNA analysis, polymer synthesis, bioprinting, preclinical in vivo facilities incl. imaging, morphology.

In particular the LBI Trauma has a long tradition in bioadhesives and hemostats. Plasma derived fibrin matrix is one of the most versatile biomaterials for tissue engineering and regenerative medicine. Being involved in a > 30 year development we can demonstrate advantages and limitations, application techniques and its special use for growth factor and cell delivery as well as a gene activated matrix.

Another goal in our group is to use „medical garbage“ for regenerative purposes.

The ACTR also provides special training opportunities (PhD program for bone and joints as well a support of the Biomedical Engineering programs).

Rodrigues **Marcelo** **Austria**

Academic University of Innsbruck

marcelo.rodrigues@uibk.ac.at

Towards an identification of the basal disc glue of *Hydra* by integrating transcriptomic and proteomic tools

The cnidarian *Hydra* is able to make strong but temporary attachments in wet surfaces owing to secretions (footprints) produced and released by ectodermal basal disc cells. Essential to our approach is to narrow down the number of proteins that are involved in adhesion and to keep track of which post-translational modifications are present in these proteins.

To achieve this goal, we i) characterized the morphology of *Hydra*'s basal disc; ii) carried out a differential transcriptome experiment to generate a highly basal disc specific database; and iii) establish a footprint specific peptide list by differential peptide mass spectrometry using our translated transcriptome database as reference.

A list of 162 transcripts that are differentially expressed in the basal disc were analysed by in-situ hybridization (ISH). Integrating the footprint-peptide list to pinpoint the matches with the ISH candidates retrieved 21 matches. Currently we investigate the functionality of the resulting proteins by RNA interference.

Slezak Paul Austria

Academic — Ludwig Boltzmann Institute for Experimental and Clinical Traumatology

Paul.Slezak@TRAUMA.LBG.AC.AT

The LBI for Experimental and Clinical Traumatology hosts state-of-the-art facilities for intensive care and regenerative medicine. With its full translational approach and an interdisciplinary team including trauma surgeons veterinarians, life scientists in particular molecular biologists, engineers, etc. it provides an optimal research environment with the special research areas of tissue regeneration (bone, cartilage, soft tissue/wound healing, neuro trauma). Furthermore it provides the necessary preclinical animal models for bone repair, required for the proposed project.

Dr. Paul Slezak has a long lasting experience in the scientific planning and execution of pre-clinical in vivo studies, including a wide variety of different species and models. He studied medicine at the medical university of Vienna and has an additional background in biomedical engineering. He manages the research group on wound healing and soft tissue regeneration at the LBI Trauma and leads the pre-clinical imaging department at the LBI.

Tilbury **Maura** **Ireland**

Academic National University of Ireland, Galway

m.tilbury1@nuigalway.ie

Recombinant expression of barnacle cement proteins

Barnacle cement proteins have huge potential as environmentally friendly adhesives due to their ability to adhere to a variety of substrates in aqueous environments. Of the characterised barnacle cement proteins, cp19k is one of the stickiest.

The cp19k gene from *Pollicipes pollicipes* fused with a leader sequence for export to the periplasm and a hexahistidine tag for detection and purification was cloned into an *Escherichia coli* expression vector. Initial expression resulted in low levels of insoluble protein.

Co-expression of trigger factor (TF) chaperones yielded purified soluble protein which co-eluted with TF resulting in a total extract yield of 7 mg/L of *E. coli* culture. Surface coat analysis demonstrated that cp19k extract exhibited high absorption on hydrophilic and hydrophobic surfaces.

Understanding adhesion mechanisms in aqueous environments will further aid the development of the next generation of surgical adhesives.

Tomoaia-Cotisel Maria Romania

Academic Babes-Bolyai University of Cluj-Napoca

mcotisel.chem.ubbcluj.ro@gmail.com

Frontier biomedical research: from multi-functional bio-interfaces to biomaterial scaffolds in cell culture

The progress over a quarter century on understanding molecular self-assemblies of various biomolecules, like, fatty acids, lipids, proteins and drugs, and colloidal characteristics of inorganic nanoparticles (NPs), such as hydroxyapatite (HapNPs), AuNPs and AgNPs, has allowed us to develop a practical strategy for syntheses of innovative nanobiomaterials.

These materials are used as scaffolds in cell culture and stimulate adhesion and differentiation of cells. Thus, new horizons are opened up from multi-functional biointerfaces and innovative materials to nanomedicine with vast biomedical applications.

The structure and properties of these materials are investigated by cutting-edge experimental tools: AFM, STM, fluorescence microscopy, SEM and TEM, LBT, DSC, BET, XRD, UV-Vis, FTIR, RMN and RAMAN. Acknowledgments: We are grateful for financial support from COST CA 15216.

Van Leeuwen Johan Netherlands

Academic Wageningen University and Research

johan.vanleeuwen@wur.nl

Secure and gentle grip to delicate biological tissues: Morphology, attachment and biomimetics of tree frogs' toe pads

Common abstract by Julian Langowski and Johan van Leeuwen

Tree frogs can hold to smooth and rough, dry and wet surfaces using their sticky toe pads. The study of the pads helps to understand the morphology and ecology of tree frogs, provides in-sights into the fundamental mechanisms of adhesion and friction in biology and facilitates the development of tree-frog-inspired, biomimetic adhesives.

Inspiration by the soft toe pads might be especially beneficial for the design of surgical grippers for wet, slippery tissues. A good understanding of the fundamental mechanisms of tree frog attachment is crucial for the successful design of a biomimetic gripper.

To answer the question, how tree frogs stick, we address this complex problem with experimental and numerical approaches as well as quanti-tative morphological analyses.

We carried out first experiments on the interaction of tree frogs' toe pads with substrates of different roughness and finite element simulations of the pad-substrate contact.

Voigt **Dagmar** **Germany**

Academic Technische Universität Dresden

dagmarvoigt@web.de

Ticks′ feet morphology and attachment

The presence of well-developed claws led us hypothesize that ticks are mostly adapted to attachment and locomotion onto rough and hairy, feltlike substrates.

However, by using a combination of morphological and experimental, biomechanical studies, we visualised the ultrastructure of attachment devices of *Ixodes ricinus* (Acarii, Ixodidae) and showed that this species adheres stronger to smooth surfaces than to rough ones.

Between paired, elongated, curved claws, *I. ricinus* bears a large, flexible, foldable adhesive pad, analogous to insect arolium, which represents an adaptation to adhesion on smooth surfaces.

Obtained microscopic and biomechanics data are discussed here against the background of general tick biology, their host preferences and epidemiology.

Voinova **Setlana** **Belgium**

Other COST Association

Svetlana.Voinova@cost.eu

COST (European Cooperation in Science and Technology) is a pan-European intergovernmental framework. Its mission is to enable break-through scientific and technological developments leading to new concepts and products and thereby contribute to strengthening Europe's research and innovation capacities.

It allows researchers, engineers and scholars to jointly develop their own ideas and take new initiatives across all fields of science and technology, while promoting multi- and interdisciplinary approaches. COST aims at fostering a better integration of less research intensive countries to the knowledge hubs of the European Research Area.

The COST Association, an International not-for-profit Association under Belgian Law, integrates all management, governing and administrative functions necessary for the operation of the framework. The COST Association has currently 36 Member Countries.

Webb **David** **United Kingdom**

Academic Newcastle University

D.Webb3@newcastle.ac.uk

Synthetic Barnacle Adhesives

Barnacle larvae (cyprids) have the ability to adhere permanently underwater to a wide variety of surfaces using a strong, proteinaceous adhesive. The purpose of this research is to produce proteins of the adhesive heterologously, in order to facilitate research into the adhesive mechanism and provide inspiration for novel, synthetic adhesives. Most commercial adhesives have drawbacks including longevity, cytotoxicity and their inability to function underwater, that prevent their use in high-value applications such as human surgery.

The barnacle system is of considerable interest, therefore. The sequence information for the uncharacterised proteins in question (Lcp's – Larval Cement Proteins - from *Megabalanus rosa*) has been provided by a collaborator: Professor Keiju Okano.

Multiple different expression strategies are being undertaken in the bacterial hosts *Escherichia coli* and *Bacillus subtilis* to obtain sufficient quantity of authentically folded protein for further characterisation work.

Wunderer **Julia** **Austria**

Academic University of Innsbruck

julia.wunderer@uibk.ac.at

Hunting for the glue: the adhesive system of *Macrostomum lignano*

The free-living, marine flatworm *Macrostomum lignano* possesses an elaborate adhesive system, which allows the animals to repeatedly adhere and release.

The adhesive system comprises about 130 adhesive organs at the tip of the tail, each consisting of three cells: one adhesive gland cell, one releasing gland cell and one anchor cell.

We identified two big adhesive proteins named *Mlig-ap1* and *Mlig-ap2* with a length of 4,600 aa and 9,400 aa, respectively. Furthermore, lectin staining revealed glycosylation of one of the two proteins.

Functional knock-down by RNA interference of the two proteins led to non-adhesive phenotypes. Ultrastructural analysis of RNAi worms showed an alteration in the adhesive vesicles in both cases whereas the structure of the cells was not affected.

These findings indicate that we have found the essential parts of the *Macrostomum* glue. Furthermore we could confirm the secretion of both glue components by analyzing footprints with Mass spectrometry.

Wyrwa **Ralf** **Germany**

Academic Innovent e.V.

rw1@innovent-jena.de

Adhesives based on polysaccharides for medical applications

The use of adhesives able to attach to wet surfaces and bind tissues together seems to be an advantageous alternative to suturing and stapling techniques. With regard to the specific constitution and mechanical characteristics of soft tissue, biopolymer-based adhesives derived from polysaccharides are promising materials in tissue repair.

Our work focuses on biodegradable polysaccharides like dextran, and chitosan, or more complex glycosaminoglycans e.g. hyaluronan to prepare cross-linkable, water-soluble macromonomers usable as adhesives in the wet soft tissue environment.

Polymeric materials with defined molecular weights have been prepared from the mentioned biopolymers. Various reactive functionalities including (meth)acrylate, aldehyde, amino and carboxyl groups have been introduced to increase their cross-linking capability.

Chitosan based systems represent promising candidates for the repair e.g. of injured mucosa tissue.

Memorandum of Understanding COST Action CA 15216

Brussels, 12 February 2016

COST 017/16

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "European Network of Bioadhesion Expertise: Fundamental Knowledge to Inspire Advanced Bonding Technologies" (ENBA) CA15216**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action European Network of Bioadhesion Expertise: Fundamental Knowledge to Inspire Advanced Bonding Technologies approved by the Committee of Senior Officials through written procedure on 12 February 2016.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA15216
EUROPEAN NETWORK OF BIOADHESION EXPERTISE: FUNDAMENTAL KNOWLEDGE TO INSPIRE ADVANCED BONDING TECHNOLOGIES (ENBA)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. "Rules for Participation in and Implementation of COST Activities" (COST 132/14);
b. "COST Action Proposal Submission, Evaluation, Selection and Approval" (COST 133/14);
c. "COST Action Management, Monitoring and Final Assessment" (COST 134/14);
d. "COST International Cooperation and Specific Organisations Participation" (COST 135/14).

The main aim and objective of the Action is to bring together experts from different scientific and technical sectors with common interests (1) to identify and characterize diverse bioadhesive systems, (2) to evaluate bonding properties and performance from macro- to nano-scale level and in the long term (3) design artificial blueprints. This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 68 million in 2015.

The MoU will enter into force once at least five (5) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14.

OVERVIEW

Summary

Many organisms, ranging from bacteria and fungi to those much larger animals and plants use chemical and mechanical means to attach permanently or temporarily to surfaces. Some bioadhesives have advantages over synthetic counterparts in terms of their ability to function over a wide temperature range, in wet or dry environments, and to form stable bonds within seconds to all manner of substrata, even those with challenging surface coatings.

Knowledge about these materials, in terms of composition, structural design and interactions with surfaces, is necessary to reveal the basic biochemical and mechanical principles involved in biological adhesion.

This COST Action European Network of Bioadhesion Expertise (ENBA) will unite the widespread European expertise in the field of biological adhesives (spanning biology, physics, chemistry, and engineering) by streamlining and pooling knowledge, methods and techniques, and will focus activities by avoiding duplication of efforts, decreasing research costs, and accelerating scientific and technological progress in Europe.

The bottom-up approach of this COST Action, integrating universities, applied research organisations and industry into an holistic program providing technical and scientific progress in understanding the fundamentals of natural bonding principles and test these natural systems *in vitro*. Knowledge achieved in this COST Action would certainly have a major impact on European academia and industrial competitiveness in the field of adhesion, nanotechnology, biomaterial and biotechnology and raise public awareness of the diversity of bioadhesives and their impact for technical applications in the future.

Areas of Expertise Relevant for the Action	Keywords
● Biological sciences: Biodiversity, comparative biology ● Biological sciences: Biological systems analysis, modelling and simulation ● Biological sciences: Biochemistry ● Biological sciences: Biophysics ● Materials engineering: Biomaterials, metals, ceramics, polymers, composites	● Bioadhesive ● Glue ● Bonding ● Biointerface ● Attachment

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

<u>Research Coordination</u>

● Many organisms are remarkable in their ability to bonds underwater, on rough, dry or dirty substrates, and over a wide range of temperatures. The Action ENBA aims to characterise these adhesive systems, understand their structural and molecular organization, function and determine under which circumstances and surface properties bonding takes place.

● Artificial structures and chemical analogues based on the natural system shall be designed and evaluated i) in view of its performance and properties related to the biological system, ii) to provide a better understanding of the key characteristics and iii) to establish protocols and technological systems for a continuing production.

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COST Association, International not-for-profit organisation/Association internationale sans but lucratif Register of legal Entities Brussels: 0829090573

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

Capacity Building

● Given the cross-disciplinary nature of bioadhesives, it is unlikely that an individual researcher would be able to tackle such a characterization alone. By knowledge transfer, research visits and easy access to a wide technical variety, ENBA will be the most effective route for the Bioadhesion community.

● The Action ENBA aims to strengthen scientific and technological knowledge for young researchers so that they could profit from the wide spectrum of advanced research technologies established in the different laboratories. Participation in conferences shall foster links within ENBA and the wider scientific community/industry working in the bioadhesion field.

● Dissemination and exploitation of Action results, methods and instrumental possibilities between participants and external experts are an integral part of ENBA. A dedicated board will coordinate all Dissemination and Exploitation activities and pave the way towards efficient and effective communication on academic, industrial and public level.

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COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

DESCRIPTION OF THE COST ACTION

1. S&T EXCELLENCE

1.1. Challenge

1.1.1. Description of the Challenge (Main Aim)

Many organisms, from bacteria, fungi and single cells to much larger marine algae and animals use chemical and mechanical mechanisms for attachment. These bioadhesive systems are unusual, because they are able to function over wide range of temperatures, in different environments, and form stable bonds within milliseconds to all sorts of substrates, often with complex surface chemistries and/or immersed in water. In addition, many bonding contacts are reversible and can be formed and released on demand by the organisms. Understanding these attachment and detachment principles, their chemical composition, physical and molecular organisation will be helpful in reaching a fundamental understanding of adhesive systems in nature.

The **European Network Bioadhesion ENBA** Action aims to specifically address the fundamental knowledge gaps that exist at all scales of bioadhesion characterization (Fig. 1), and which must be understood before significant progress can be made. The Action will bring together experts from the different scientific fields and technical sectors with common interests; **(1)** to **identify and characterize** a wide range of bioadhesive systems, **(2)** to **evaluate** bonding properties and performance from macro- down to nano-scale from different perspectives (adhesive side, interphase, adherend side) and, in the long term, also **(3)** aim to **design artificial blueprints** to test these principles *in vitro*.

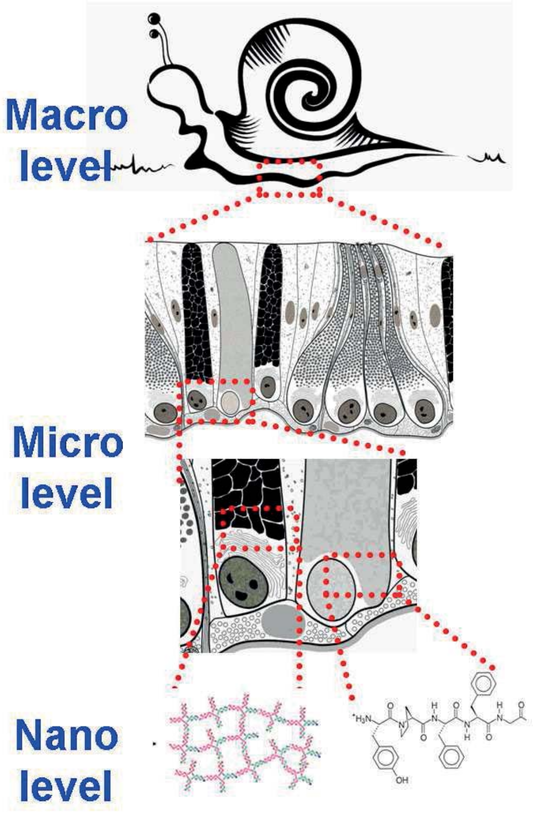

Fig.1: Contribution of the COST Action **ENBA** in the interdisciplinary characterization of biological adhesive system

The scientific and technological activities of the Action will be devoted to improving the divided European Research Area in this field, overcoming the bottlenecks in bioadhesive identification and characterisation, developing and sharing the specific technical resources required for investigation of bioadhesion, and thus accelerating scientific and technological progress for the European research community.

1.1.2. Relevance and timeliness

Synthetic adhesives and sealants such as epoxy, cyanoacrylate, polyurethane or polyimide have become a significant part of our lives. Their applications range from the transportation (cars, trains, and aircrafts), electronics, clothing, food and pharmaceutical packaging to safety products in the medical sector (Fig. 2).

Despite the multi-functionality of synthetic adhesives they are not simple products and often the use of toxic components is required. In particular areas where these substances may come in direct contact with the human immune system (e.g. such as dental filler, medical adhesives and sealants, but also cosmetic and beauty products, baby toys and numerous house-care products, school and stationery products, clothing, wood construction, etc), epoxy, formaldehyde and cyanoacrylate resins are inappropriate, yet still used despite their known toxic and carcinogenic side-effects.

In the medical sector a few biocompatible alternatives such as fibrin and serum-based adhesives (Fig.3) exist, but are limited to a few applications (Blume and Schwotzer, 2010).

In nanotechnology, 3D printing, nanomedicine, robotics, regenerative medicine, microelectronics and nanosensors, the requirements for adhesives and sealants (small particle size, temporary fastening systems, lack of chemical cross-reaction, low temperature, self-assembly, nanolayer thickness) are much higher than today's synthetic adhesives could reach.

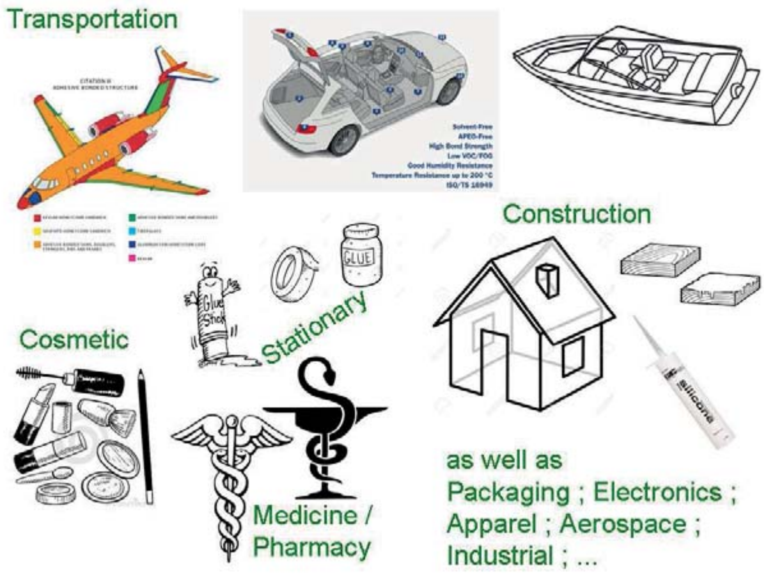

Fig.2: List of major markets in which synthetic adhesives and sealants are widely used

With increased interest for biocompatible and biodegradable components in human-focused fields such as biomedicine, nanotechnology and tissue engineering, bioadhesives are a **relevant and credible alternative** to the current toxic or weakly bonding adhesives. Bioadhesives could fulfil the demands and requirements of established and emerging areas, such as:

Fig.3: Medical adhesives and their negative side effects to the human body

- ☺ biodegradable
- ☺ non-toxic in nature
- ☺ providing a strong adhesive bond in dry, moist and/or wet environment
- ☺ adhering to different surfaces/materials and bridging materials of varying modulus
- ☺ achieving permanent or temporary fastening mechanisms
- ☺ consisting of different viscosity grades and bonding forces
- ☺ useful for manipulation at the nano-scale
- ☺ self-assembling after secretion
- ☺ lack of exothermic reaction during polymerization
- ☺ are of natural origin and provide low chemical reactivity to most other biomaterials

To develop new biomaterials, therapies and technological approaches including bioadhesive systems or components, it is necessary and timely to understand first the fundamental mechanisms that govern and control bioadhesion. Comparison of diverse adhesive structures, chemical compositions and physical properties in relation to their natural context will lead to a comprehensive view of bonding strategies and mechanisms in nature and identify unifying principles and function-specific adaptations. In this way the research community can overcome current scientific and technical bottlenecks of bioadhesion research and provide progress in a field that has potential to revolutionise diverse sectors, industrial applications and commercial products.

1.2. Specific Objectives

1.2.1. Research Coordination Objectives

„There are therefore agents in nature able to make the particles of bodies stick together by very strong attractions. And it is the business of experimental philosophy to find them out“

Following the direction of Isaac Newton, the central objective of the COST Action **ENBA** will be to develop a profound multi-disciplinary understanding of adhesion in nature and the fundamental chemical and mechanical principles involved. This objective necessitates **(1)** the characterization of bioadhesion phenomena at multiple scales, **(2)** understanding bonding principles at the molecular level as well as **(3)** similar adhesive performances in artificial systems.

1.2.2. Capacity-building Objectives

While the US and South Korea are leaders in bioadhesion research, their focus is mostly directed towards the adhesive system of marine mussels and geckos and the contributions to the field stem from a very small number of institutes and persons.
Europe, by contrast, is very diverse with respect to the variety of organisms (plants/animals, marine/terrestrial, dry/wet adhesives, temporary/permanent bonding), basic and interdisciplinary research fields (nanoscience, theoretical and applied mechanics, physical chemistry, zoology, botany, chemistry, engineering, material science, biophysics), and objectives (fouling avoidance, medical sealants, biomolecular phylogeny, nanomaterial linkage, soft robotics, hybrid design, etc.) under investigation. This diversity presents a highly conducive environment for innovation in Europe, with huge potential for future implementation of scientific outcomes in the commercial sector. Despite this, the many scientists and companies involved in adhesion research, and the diversity of end-users, remain poorly networked. In the absence of large, integrated, Action projects, effective knowledge exchange and coordination of research/technical approaches is restricted to small subsets, hampering comparative studies and impeding identification of fundamental principles.
Moreover, common communication platforms and dedicated meetings which exist for academics in the US (e.g. Annual Meeting of the Adhesion Society, Gordon Conference Science of Adhesion) and European bonding industry (e.g. FEICA European Adhesive & Sealant Conference, European Coatings Show) are missing for European academics.

The broad aims of the COST Action **ENBA** are as follows:

- Within the scientific community, to stimulate communication, collaboration and networking between European researchers in the fields of adhesion and biologically-inspired adhesion, as well as in related fields (e.g. Tissue Engineering, Nanotechnology, Robotics, Microelectronics).
- To pool together resources in this new technical network, in particular specialist methods and analytical techniques independently developed in different laboratories in Europe as well as to share samples, organisms and instruments for comparative analyses. Novel methods will be adapted for adhesives research and standardized.
- A training network will be dedicated to educating young researchers by cross-cutting exposure to all aspects of adhesion and its applications i.e. in biomedicine, construction, cosmetics and electronics.

From a quantitative point of view the achievements of these research and capacity-building objectives can be evaluated by the following parameters:

- Number of presentations, publications and patents originating from collaborative research, the latter representing experimental achievements generated in the COST Action
- Number of trans-national collaborative research proposals prepared
- Number of institutes and companies participating actively in the network
- Number of Short-Term Scientific Missions (STSMs) supported by the Action
- Number and diversity of training activities, and number of people trained

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COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

1.3. Progress beyond the state-of-the-art and Innovation Potential

1.3.1. Description of the state-of-the-art

Bioadhesives from plants and animals have proven their efficacy for 500 million years and been adapted throughout to suit the needs and requirements of the organism producing them. However, still very little is known about the composition, production, secretion and mechanical properties of the vast majority of these systems. Generally speaking, bioadhesion tends to be based on **two principles**:

(i) Attachment via **mechanical systems** and interfacial forces, i.e. by van-der-Waals-forces or capillary interactions as seen in geckos, flies, beetles, tree frogs and ivy, or by reduced-pressure systems (Federle et al., 2006; Gorb et al., 2007). Among these systems, hairy and smooth toe pads have been studied most extensively, and the structures present on gecko and tree frog feet have become model systems with successful prototypes and applications.

(ii) Adhesion via **glues and chemical bonds.** This principle allows many algae and numerous invertebrates like molluscs, crustaceans (barnacles), insects as well as vertebrates (salamanders, frogs) to adhere strongly, either permanently or temporarily (Smith and Callow, 2006; von Byern and Grunwald, 2010) by the use of specialized proteins or other macromolecules. These glues may not only be used for an organism attachment to the substratum but also for other strategies such as prey capture or as defence.

This diversity of organisms, adhesive systems and their specific functions makes bioadhesion research challenging, not least because both of the above principles are commonly involved in biological adhesion processes. Further, many species have optimized their adhesive structures and systems for different purposes, under different conditions/environments and the specific requirements of the particular organism producing them. As a consequence even closely related species may differ in their adhesive production, morphology and composition,
To date, only around 30-40 marine and terrestrial organisms are described generally to adhere by chemical substances (see contributions in Smith and Callow, 2006; von Byern and Grunwald, 2010) and of these only 5-6 organisms have already been characterized in detail or implemented into functional prototypes. However, there is a huge number of species, for which the process of adhesion has been observed, but for which the functional principles and/or broad composition of the adhesives remain unknown. This primarily may be due to a historic lack of access to advanced technological approaches and financial support. Despite these obstacles, the diversity of nature is clearly a blessing from a bio-prospecting perspective, providing countless opportunities to identify commonalities and functional principles, thereby developing a better understanding of adhesive mechanisms, evolutionary origin and adaptations to specific environments.
The key to unlocking this lies in comparative analysis with innovative research approaches based on intellectual and technical exchange. Key requirements, previously lacking, are the necessary personnel and financial capacity to perform such multidisciplinary studies. First however, a cohesive community of dedicated expertise must be consolidated.

1.3.2. Progress beyond the state-of-the-art

In terms of public awareness the “**gecko foot**” is surely the most recognisable natural adhesion system. In recent years several groups worldwide have made good progress in developing inspired

adhesives by mimicking the geometry of ‘hairy’ systems at different scales (Geim et al., 2003; Peressadko and Gorb, 2004; Crosby et al., 2005), leading to applications as **GeckSkin™** and ***Gecko® Nanoplast®***. Bio-inspired patterned adhesives have already been tested successfully on small robots, allowing them to climb vertical smooth walls for engineering applications, and on living soft tissues for medical applications (Daltorio et al., 2007; Mahdavi et al., 2008). Winter tyres with honeycomb profiles (Continental) were also inspired by biological attachment systems, such as smooth tarsal pads of grasshoppers and the toes of tree frogs (Barnes, 2007).

The biomimetic adhesive **"Geckel"** was the first attempt at combining hierarchically the respective bonding systems of gecko and mussels. Bivalve molluscs, such as the mussel ***Mytilus edulis*** rely on the so-called byssal thread system for adhesion; providing a tight and permanent bond (tensile strength ≈ 0.3 MPa) on a wide range of natural substrata (rocks, wood, seaweed or other animals) and even on man-made surfaces as Teflon®. Six different mussel adhesive proteins (MAP) and collagen form and maintain the holdfast. The tissue adhesive **Cell-Tak**™ (USA) was the first example (year 1986, TM-No. 73604754) of a marine-derived sealant, based on MAP only. With the produc
tion of recombinant MAPs since 2006, new scientific and technological opportunities as well as tailored products (MAPTrix™**,** Mgfp-5 analogues, LAAC, etc.) for the tissue engineering and cosmetic applications arose. Recently, **expertise** in **recombinant** MAP **production** has increased but, in parallel, progress has become **centred** more and more towards the **Asian region** as it is evident from the growing number of patents, publications and in particular applications in the nanomaterials, tissue engineering and biomaterial sectors.
The four examples described above show clearly that bioadhesives could yield meaningful and practical applications. However, as these systems only work under specific environmental conditions, e.g. the mussel adhesive proteins bond well under wet conditions but weakly on dry surfaces, these adhesives are predestined for selected market sectors and could not be applied universally.
Other gluing systems in the future could be based on the secretions of frogs, barnacles, glowworms, sea cucumbers or yet unknown organisms, and lead to a completely new fastening systems with novel capabilities, opening up new markets, advancing existing sectors and inspiring new products from surgical sealants to microelectronics.

1.3.3. Innovation in tackling the challenge

Although micro- and nanotechniques (scanning electron microscopy (SEM), atomic force microscope (AFM), microarrays, molding, microthermoforming, photo-activated localization microscopy, stochastic optical reconstruction microscopy, etc.) are well established and allow the characterization and development of small structures and components, their applicability to bioadhesives research is still limited. The 3D complexity, heterogeneity in composition and inaccessibility of biological structures present challenges for reproducible measurements (i.e. AFM) and existing molecular protocols and tests are designed principally for model organisms, requiring large amounts of pure material. In reality, most organisms of interest produce tiny amounts of material or present challenges to handling. Although applicable, therefore, most cutting edge analytical techniques require significant optimisation if their potential in bioadhesion research is to be realised.

Working Group structure

In **Working Group** (WG) **1 "Learning from nature – structure-function relationships"** the participants aims to gain sufficient knowledge of the organisms' bonding mechanisms and determine under which circumstances and surface properties bonding takes place. Due to the diversity and uniqueness of bonding systems in different marine and terrestrial organisms, many of which differ greatly from the two well-known models (geckos and mussels), the characterization and understanding of these requires an **interdisciplinary effort** and a **holistic strategy**, identifying as many organisms as possible, performing bioadhesion measurements and characterizing the biological systems as well as at the **macro, micro and nano level:**

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

	Organism side	Interface	Adherence side
Macro	Surface geometry (i.e. stereo/light microscope level, microcomputer tomography/µCT), surface properties, attachment/detachment behaviour	Secretions: rheology, wettability on different substrates, time and strength of bonding, detachment strategies, 3D structure (µCT)	Surfaces: types, topography, mechanical properties
Micro	Ultrastructure of attachment/gland area (i.e. electron microscopy, immunolabelling) and surface energy (i.e. wettability)	Physical and chemical interactions of bonding area/glue with the substrate surface, mechanical properties of the glue and its bonding strength at small scale (microforce tester)	Surface microtexture (i.e. profilometry, white-light interferometry) and surface free energy (contact angle measurements)
Nano	Chemical composition, protein sequencing and gene profiling (biochemistry ; molecular biology), nanostructure and molecular organisation of the bonding area	Orientation/arrangement of specific molecules and functional groups of dry and wet adhesives on surfaces	Nanostructure and molecular organisation of the specific substrates (SEM, AFM)

It is not always possible to study and perform extensive tests with organisms *in vivo* due to limitations on sample numbers, repeatability and instrument specifications. To address this approach, **Working Group 2 "Artificial Models – understanding bioadhesion *in vitro*"** will design artificial structures and chemical analogue biomolecules based on the original bioadhesive system to provide a technological alternative and offer additional possibilities in studying the biological model. Characterization and evaluation of the analogous structures and biomolecules at the macro, micro and nano level serve ***i)*** to characterize their performance and properties in relation to the biological system, ***ii)*** to provide a better understanding the influence of key characteristics and ***iii)*** to establish protocols and technological systems suitable for a continuing production for further investigations.

Sharing of Knowledge and Technology:

It is anticipated that large national/multi-national grants will be secured over the Action period to support the research efforts of the network. However, even if this is not the case, significant progress can still be made using resources currently available in Action participants' labs. It will nevertheless be essential for both WGs to engage in comparative and cooperative studies, information and data sharing to avoid duplication of effort and ensure scientific and technological progress with or without additional funding, ***i)*** by testing and optimising new methods and techniques for different organisms, ***ii)*** by establishing and sharing successful protocols and techniques, ***iii)*** by joint use of infrastructure and instruments and ***iv)*** by integrating different research fields, other COST Actions (e.g MP1301, MP1303) and coordinating European projects (e.g. Byefouling, SeaFront) and researchers worldwide into **ENBA**, providing scientific and technical support and expertise in relevant topics and research disciplines:

In the field of **mechanical systems,** different techniques and nanotools (i.e. UV, electron beam or deep X-ray lithography, 3D printing, hot embossing, etc.) are well established, enabling to design and fabrication of 3D structures based on a biological templates (e.g. beetle feet). Specialists from different fields (e.g. microfabrication, tribology, materials & polymer science, robotics, biotechnology, nanoscience, protein biosynthesis, etc.) as well as other COST Actions, EU or national projects will be invited and encouraged to participate in the design and fabrication of artificial microstructures varying in key physical properties.

From what is known to date, most natural glues contain relatively few types of biomolecule (proteins, sugars or lipids) and these molecules often require only a few key components for a secure bonding, e.g. L-DOPA in the mussel system. However, to fully understand the mechanism of action, it is not sufficient to simply identify the molecular units present. Modelling studies and detailed characterization are necessary to determine structural and functional elements within the biomolecules and by this understand their interaction and bonding mechanisms to different surfaces and materials.

1.4. Added value of networking

1.4.1. In relation to the Challenge

Current education practices largely still follow the classic disciplinary curriculum including biology, chemistry and physics, usually with limited cross-pollination. Since the variety of topics in bioadhesion research requires a broad range of techniques and practical competences (which cannot be developed in every individual laboratory), it is necessary to pool knowledge in general and infrastructure and technical diversity in particular to convert biological adhesives into biomimetic industrially applications. Through **ENBA** the participants will significantly profit from the continuous flow and input of scientific and technological knowledge, expanding their methodological skills and able to incorporate data and methods from different research fields into their own studies.

The journal "Adhesion, Adhesives and Sealants" has specified a **growing need** and **urgent demand** for **skilled employees** and trainees for European companies. Interdisciplinary projects involving industrial participation are indispensable, not to only to attract junior scientists for such complex studies but also to promote the transfer of research into technology and thus keeping Europe at the leading edge of bonding technology. **Intersectoral co-operation** through industrial-academic partnerships and STSMs between institutions from different participating COST Countries are the best way for young researchers to acquire analytical and **advanced research expertise**, integrating these into a highly active European-wide research network, advantageous for career development and providing academic study with socio-economic context.

1.4.2. In relation to existing efforts at European and/or international levels

At the **European level,** the use of adhesives from marine organisms for novel applications in the industrial, medical, cosmetic and biomaterials sectors has so far been considered 'beyond reach'. The thematic focus in the EU frameworks has been centred mostly on the Avoidance/Blockage of marine adhesives and financially sponsored (*≈ 30 Million Euro*) in numerous projects (AMBIO, ULTRACLEANPIPE, CLEANSHIP, BIOFOULCONTROL, FOUL-X-SPEL, SEAFRONT, BYEFOULING, etc.). Only 2 projects (FP5 Algal Bioadhesives and FP6 BLUE4GLUE, with a total EU contribution *≈ 3 Million Euro*) have addressed the issue of bioadhesion. Despite this limited funding, the start-up company Sealantis Ltd. from Israel successfully demonstrate the potential impact of EU-funding, offering algae-mimetic adhesives and gels (i.e. Seal-V™) for surgical applications.

The first and only bioadhesion relevant COST Action (**TD0906** "Biological adhesives: from biology to biomimetics") was funded from 2010 to 2014. This communication platform catalysed the formation of a brand new natural adhesives community in Europe and demonstrated that productive collaboration in this field is required. Around 180 participants, comprising 44% female and 51% male researchers participated in this Action network, > 90 joint publications and 6 national and European research projects (focusing on biological adhesives systems) were delivered.

The present **ENBA** proposal builds from the foundation of Action TD0906, **identifying** its **strengths** and **learning from** its **weaknesses**. Indeed, although this former Action had two goals, ***i)*** the characterization of natural adhesives and ***ii)*** the development of bio-inspired counterparts, by the end of the Action it was clear that only the first goal had been fulfilled with the latter remaining out of reach due to **lack of sufficient fundamental knowledge.** This conclusion is further corroborated by the fact that the only effective biomimetic adhesives produced to date are inspired by geckos and mussels, for which there was tremendous (decades) prior research effort upstream. In the present **ENBA** the Action members therefore aim to **take a step back** and **focus** on the **fundamentals** - techniques and basic principles that will serve to underpin research into the various bioadhesive systems. This thematic approach therefore differs significantly from TD0906, being more realistic in terms of its objective to provide key underpinning knowledge and capabilities, rather than developing new products from scratch.

At an **international level,** US, Korean and recently Chinese groups/companies are in the lead by far, developing functional biomaterials and products based on MAP. This has been made possible, due to their ability to produce MAP recombinantly in large quantities and engineer highly sophisticated application methods.

2. IMPACT

2.1. Expected Impact

2.1.1. Short-term and long-term scientific, technological, and/or socioeconomic impacts

The present COST Action will continue to **unite** the widespread **European expertise** and **activities** in the many disciplines associated to bonding technology, streamlining and pooling knowledge, methods and techniques as well as fostering close alliances with other research sectors and industries in which bioadhesives could provide technological alternatives and facilitate new possibilities.

Short-term impacts (within the COST Action period)
ENBA will be multidisciplinary, welcoming researchers and industrial participants from different fields, sectors, and backgrounds to identify and characterise novel, previously uncharacterized structures and materials using holistic approach. The involvement of different research fields with their diverse methods will not only provide for the Action members a world-leading scientific and technological resource, but also bring benefit to external researchers through the results and technological innovation. Furthermore, with the multilingual websites, ENBA will provide the interested public, industry and policy makers with an information hub demonstrating the potential reach of bioadhesives

Long-term impacts (beyond the COST Action period)
In the long term ENBA will enhance many-fold the existing cooperation and research in this field. The network will strengthen the position of researchers and companies alike for future implementation of product ideas and a wealth of novel materials spanning industry and biomedicine. With detailed knowledge of glue composition and genetic/biochemical profile of glands or microstructures, the scientific community will have an invaluable resource to draw upon.

Technological impacts
Development, adaptation and standardization of new and existing methods (i.e. molecular biology, biochemistry, tribology, friction) for bioadhesive research will be useful for other research areas dealing with the identification of substances (i.e. biomaterials, toxins, proteins, etc.) and structures (i.e. soft robotics, fastening systems). The technical impact in terms of understanding adhesive systems will provide the basis for the development of new, alternative mechanical or chemical bonding systems.

Socioeconomic impacts
The achievements of ENBA will surely provide **in the long term** novel biomimetic solutions with broad societal, environmental and economic impacts. Stakeholders such as ***a)*** adhesive and sealant industries could profit through the development and production of environmentally- and eco-friendly adhesives; ***b)*** biotechnology & bioproduct companies could implement novel biomaterial and composites with adhesive biomolecules and ***c)*** the robotics and electronics industries will be able to develop novel products and applications drawing upon novel attachment strategies.

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

2.2. Measures to Maximise Impact

2.2.1. Plan for involving the most relevant stakeholders

Stakeholder	*ENBA* outcome	Expected impact
Research community		
All European scientists and institutes working in the field of bioadhesion or biomaterial	Characterization of diverse adhesive model organisms	✓ New knowledge on bioadhesive systems ✓ Standardisation of techniques and methods for the bioadhesive community ✓ New inspiration for the material science and applied research institutes ✓ Technological progress also useful for other research areas and fields ✓ Increase of scientific publications, grants & protocols in this field
All interested researchers/persons/ companies	Bioadhesive website platform	✓ Exchange of data and publications ✓ Showing presence in Europe ✓ Public Communication and Engagement ✓ Networking of national researchers & knowledge exchange
General Public, Consumers & Policy makers		
All persons interested in science and biological phenomena	Health products	✓ Raise public awareness of given commercial adhesives side effects
	Bioadhesion characterization	✓ Highlight the diversity of bioadhesives and their prospective benefit ✓ Meaningfulness and need of such research
Adhesion societies; national and European agencies	Bioadhesion research & networking	✓ Aware of necessity to support and promote bioadhesion research in Europe ✓ Appearance as European Bioadhesion community
SMEs & industry		
Private public partnerships, spin-off	Innovative concepts for biomimetic applications	✓ Strengthen of the collaboration with the industrial sector
Applied research institutes; SME	Bioadhesive website platform	✓ Inspiration for new applications in the industrial sector ✓ Information about the progress and activities of the European Bioadhesion community

2.2.2. Dissemination and/or Exploitation Plan

Dissemination and exploitation of the Action results (**WG3**) are an integral part of ENBA and will be the particular responsibility of the Dissemination & Exploitation Board (**DEB**), consisting of three elected MC members. The dissemination activities of DEB include:

- ✓ set-up and maintain **continuous performance** throughout the COST Action, enabling an **efficient communication** between the Action members
- ✓ coordinate, evaluate and disseminate all National, European and International D&E activities

scientific, technological and public outreaches within the network and towards external stakeholders
- ✓ organise **Pan-European dissemination activities**, i.e. providing a European "*Adhesion Day*" and support local and national dissemination and exploitations campaigns
- ✓ participate at **international meetings** (World Biomaterials Congress 2016 Canada; Annual Meeting of the Adhesion Society USA; Annual Meeting of the Society for Adhesion & Adhesives), industrial road shows, trade fairs and launches to promote ENBA and discuss synergies
- ✓ set-up and run Action **website**
- ✓ pursue **contact** and **cooperation** with relevant thematic COST Actions, European and national projects, researchers and companies
- ✓ prepare **multilingual press releases** & public relation material for all ENBA members for effective promotion during national public outreach activities
- ✓ create a **corporate identity** within the Network (e.g. logo and ENBA poster) presenting the COST Action aims and outcomes at the different conferences and symposia

In addition to this dedicated Pan-European activities, all **MC and Action members** will be encouraged to perform local and national activities, publicity campaigns and, by this, promote ENBA as well as its thematic outreach. The members, may they be academic, private, RTD, SME or industrial participants, will be encouraged to use their **business and scientific networks**, participate in **research societies** and publish in **industrial journals and magazines** to promote ENBA and to inform not only stakeholders, customers and the general public but also national **coatings, adhesives and sealants manufacturers** about ENBA and its objectives. All Action members should take part and refer to the COST Action in:

- ✍ lectures and laboratory courses within the academia and for public
- ✍ science correspondence in national and international newspapers and magazines (e.g. Universum, Geo, National Geographic, Scientific American)
- ✍ popular media (radio, newspaper and TV interviews) and social networks (Twitter, Facebook, scienceblogs, LinkedIn, Youtube) to make the Action more accessible for different audiences
- ✍ different national activities such as high school science fairs, student's and children's universities, "university meets public", "long night of science", exhibitions, etc.
- ✍ at conferences, meetings and in publications

Exploitation activities
The DEB will take an **integrative overview of the exploitation of ENBA results and technologies** across the whole Action and take care of:

- Identify funds, grants and other useful resources suitable to support research in the COST Action and, in particular, the more resource-intensive WGs 1 and 2
- Identifying knowledge that could be subject matter for protection through patents or publications
- Developing and distributing standardized methods and successful protocols within the Network

General guidelines with regard to **intellectual property** and **confidentiality** (also in view of publication authorship & patent applications) are subject to the **agreement** between the MC members and these will be set up at the outset of the COST Action, containing arrangements about the management of foreground and background knowledge, Intellectual Property Rights during and beyond the Action.

2.3. Potential for Innovation versus Risk Level

2.3.1. Potential for scientific, technological and/or socioeconomic innovation breakthroughs

Scientific breakthroughs
It can be assumed that the potential for scientific innovations within **ENBA** is high (indicating a low risk level) since each and every bioadhesive system characterized will represent a stand-alone contribution to understanding. The impact of these contributions will be compound, with every piece of information adding to the greater picture. In the long-term, every finding that will emerge from the network through collaboration and information sharing will improve understanding of structures and biomolecules

involved and, thus, the likelihood of impact.

Technological breakthroughs
The design and testing of artificial and hybrid models in WG 2 will demonstrate the understanding of the bioadhesive templates and the ability of the network to implement this knowledge. Although some attempts will fail, these will contribute clearly to the technological understanding and appreciation of knowledge deficiencies. Artificial models which correspond functionally and/or technologically to the biological original will constitute breakthroughs to inspire new innovations.

Socioeconomic breakthroughs
Novel products and materials based on bioadhesives could provide huge socio-economic advantages as shown above, and progress will raise awareness of human-friendly alternatives to current technologies. Nevertheless, the Research & Development of any biomimetic products, may it be a bioadhesive or other, is still risky in view of regulatory aspects, environmental safety and its failure in practice. Yet, products such as MAPTrix™, Cell-Tak™ , GeckSkin™, Seal-V™ and others show clearly the possibility and potential of bioadhesives, as long as the knowledge of the adhesive system, bonding mechanism and function is properly understood.

3. IMPLEMENTATION

3.1. Description of the Work Plan

3.1.1. Description of Working Groups

WG 1: Learning from nature – structure-function relationships
Objectives
- ✓ to identify bonding organisms and provide insight into the adhesive structures and secretions
- ✓ to determine physical properties in terms of adhesion strength, rheology, wetting capabilities
- ✓ to develop a platform for sharing knowledge, procedures, specimen and instrument analyses

Task 1.1: Morphology/Structure
Adhesive systems possess complex hierarchical structures from the macro- to the nanometric scale. Their structural organization and synthesis is important for their function and structural composition. Therefore, broad comparative studies using e.g. different life science imaging techniques (i.e. SEM, AFM, Confocal Laser Scanning Microscope, Energy dispersive X-ray spectroscopy) will be carried out in order to understand essential structural principles behind their functions and determine changes during development.

Task 1.2: Composition/Profiling
The focus is **(i)** to identify and characterize structures of dry and wet adhesives chemically, **(ii)** to develop sample preparation and extraction procedures for wet adhesives, **(iii)** to discuss and adapt general chemical characterization approaches of the different glues including their biomolecular composition, amino acid/monosaccharide sequence and spectral features and **(iv)** to optimise the identification of the most abundant (glyco-) proteins and peptides.
Understanding the underlying molecular network and genes controlling glue synthesis is a crucial step towards understanding glue formation, bonding and curing mechanisms, as well as providing knowledge of the relevant key molecules.
State-of-the-art technologies will include chromatography (i.e. High-performance liquid chromatography), biochemical techniques (i.e. SDS-Page Gel electrophoreses, Matrix-assisted laser desorption/ionization time-of-flight mass spectrometer/imaging) as well as molecular tools (i.e. *de novo* transcriptome/genome sequencing), which are available in the different labs of the ENBA participants.

Task 1.3: Properties/Performance
To understand the detailed function of biological adhesives, it is essential to observe the process of

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COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
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attachment and release with high spatial and temporal resolution, as well as to measure the adhesive performance under natural and standardised conditions. Relevant experimental approaches include force and contact area measurements, surface energy estimation, and roughness characterisation. The data on the mechanical performance of adhesives will be used to test theoretical models of adhesion, to prove possible correlations between different organisms and systems and to identify new principles or new combinations of principles that result in strong adhesion.

Activities: Research coordination, Publications, Conference Proceedings, STSMs, Training Schools

Milestones:
M1.1: New state of the art book of "Bioadhesion methods & diversity" (Month 40)
M1.2: Final Report (M48)

Major deliverables:
D1.1: At least one Training School for each task (Annual)
D1.2: Records of dissemination and public relation activities (6-monthly)
D1.3: Progress report comprising the number of STSM and publications for each task (Annual)

WG 2: Artificial models – understanding bioadhesion *in vitro*

Objectives
- ✓ To design and characterise artificial micro- and nanostructures supporting adhesion
- ✓ To characterize and model adhesion properties of biomolecules
- ✓ To determine and characterise adhesion properties in hybrid systems

Task 2.1: Topography design/evaluation
Test the role of hierarchical structures (macro- micro– nano level) defined in WG1 in combination with biomolecules and test their contribution to adhesion at the interface. Artificial micro- and nanostructures of similar geometry will be designed and built using lithography techniques, 3D printing, electrospinning, Focus Ion Beam scanning electron microscopes, etc., and test their role in adhesion using a broad range of force measurement techniques.

Task 2.2: Biomolecule characteristics/processing
The goal of this task is to understand, measure and model the 'stickiness' of bioadhesive molecules in detail. Advanced molecular simulations and detailed measurements i.e. by surface plasmon resonance, atomic force microscopy and others will be employed (according to WG 1) to the artificially developed biomolecules to characterise substrates and the key proteins, generate in-depth information relating to adsorption/adhesion to different chemical functionalities and the nanomechanical properties of the molecule. As tests with purified biomolecules may not be sufficient in terms of amount or polymer length, production of biomolecules via chemical synthesis or recombinant techniques will be discussed with experts from other relevant disciplines and implemented into this task.

Task 2.3: Hybrid systems
To understand the mutual influence and effect of different biomolecules and bonding principles, models from task 2.1 and 2.2 will be combined into hybrid and multi-response systems such as hydrogels (Krogsgaard et al., 2013), polymers (Kumar Roy and Prabhakar, 2010) or other materials. Characterization and measurement of these systems will serve to provide additional knowledge on basic bonding principles.

Activities: Research coordination, Publications, Conference Proceedings, STSMs, Training Schools

Milestones:
M2.1: Interim report (Month 24)
M2.2: Final report (Month 48)

Major deliverables:
D2.1: At least one Training School for each task (Annual)
D2.2: Records of dissemination and public relation activities (6-monthly)
D2.3: Progress report comprising the number of STSM and publications for each task (Annual)

WG 3: Dissemination & Exploitation

Objectives

✓ To strengthen the International and European visibility of Bioadhesion research

✓ To establish exchanges and collaborations within adhesion, biomaterial and other communities

✓ To promote the dissemination of expertise, methods and results

Tasks:

WG 3 is dedicated to coordinating, monitoring and by this guaranteeing optimal visibility of **ENBA** at academic, industrial and public levels. The **DEB** will be responsible for organisation, performing and evaluating pan-European activities and to effect efficient communication both internally and externally. Further details about the aimed D&E activities and strategies can be found in section 2.2.2.

Activities: Press releases, Electronic newsletters, Roadshow participation, Conference organisation, Campaigns, Activity Days

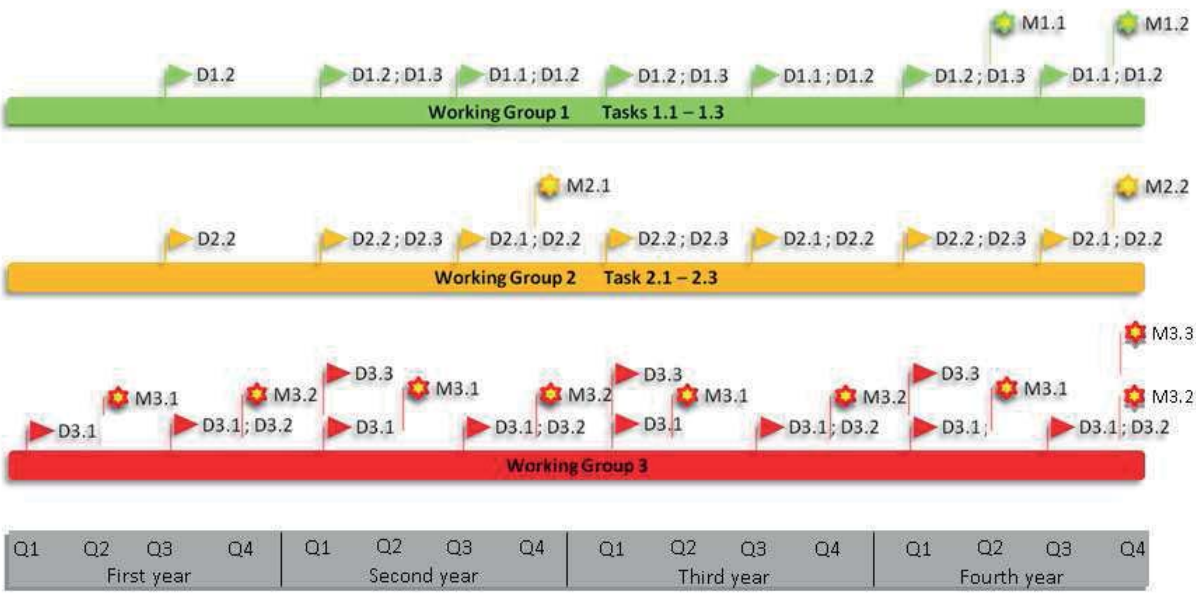
Milestones:

M3.1: Multi-lingual Action website (Annual)
M3.2: Conference for WG 1 and WG 2 (Annual)
M3.3: Final Report (M48)

Major deliverables:

D3.1: Electronic newsletter (6-monthly)
D3.2: Progress report (Annual)
D3.3: Activity Day (Annual)

3.1.2. GANTT Diagram



3.1.3. Risk and Contingency Plans

Risk relevant for WG1:

Failure of adhesive characterization and/or identification of key molecules in organisms

Contingency plan:

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Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

The network has considered this and all participants involved are aware that ENBA may not be able to fully characterize the adhesives of all organisms. However, for several organisms preliminary results and data are already available for further study within WG1.

Risk relevant for WG2:

Delay, failure or insufficient technological progress designing and building artificial models

Contingency plan:

To minimize this risk, several network participants will work parallel on these tasks to find optimal specifications and set-ups. Furthermore, external and international researchers will be invited to join WG2 and participate in the technological set-up and implementation.

Risk relevant for all three WGs:

One or more Action members show weak commitment to the network progress, task participation and dissemination activity or leave the Action

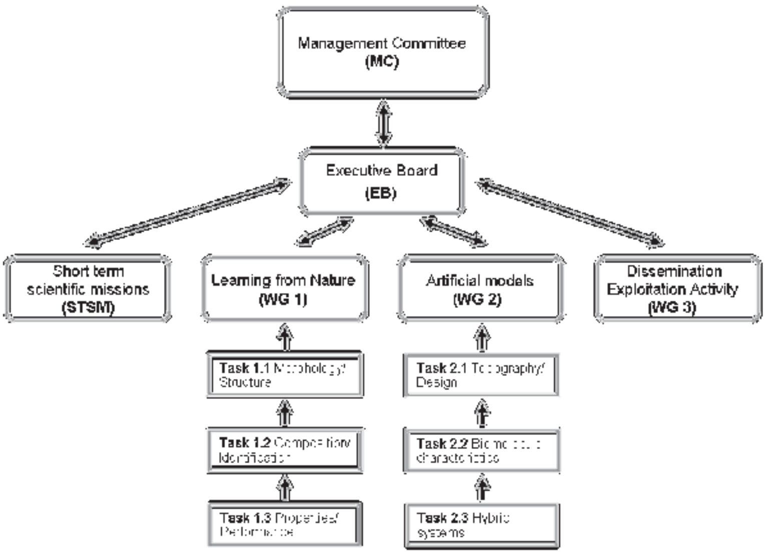
Contingency plan:

The MC and EB will supervise the effective communication at all management levels to avoid misunderstanding and ensure an optimal internal and external outreach. In the event of a loss of a participant having an important role the MC will look for alternatives and discuss alternative management structures to compensate and substitute the member lost in the relevant tasks.

3.2. Management structures and procedures

ENBA will be managed by the **Management Committee** (MC). This MC will be responsible:

- To implement and set the strategic direction of the Action
- To elect the Executive Board (EB), STSM Coordinator, the WG1&2 Leaders and D&E Board (WG3)
- To supervise, monitor and give recommendations to the boards and coordinators
- To coordinate the scientific, technical and financial progress of the Action
- To address and document all issues raised by external regulatory and other bodies relevant to the objectives of the Action
- To coordinate and perform all COST Action activities, scientific and public outreach
- To elect and include participants to the network



The **Executive Board (EB)** will be elected from the MC members at the first MC meeting of the Action. It will comprise the Chair, the Vice Chair, the STSM Coordinator and WGs Leaders. The EB will steer and monitor the COST Action on behalf of the MC as formally approved by the MC.

Short-Term Scientific Missions (STSM) will be actively used to enhance information exchange, for research trips for use of special instrumentation or know how, and to enable young researchers and senior experts to participate in inter-group programs. STSM applications must be related to one or more of the six tasks (1.1-1.3 & 2.1-2.3). The **STSM Coordinator**, elected at the first MC meeting will then further evaluate the value of the STSM prior to approval by the EB. This procedure will be completed by email to avoid delays.

WG 1&2 and their tasks will be coordinated by an expert member, elected during the first MC Meeting, while **WG 3** comprises a board of three voted MC members (one of these participates also in the EB). The Leaders of each task will be elected during the first Kick-off WG Meeting. The task meetings will be chaired by the respective WG coordinator and regularly

- ✓ review progress and timelineness of all tasks & outreaches
- ✓ ensure effective coordination and implementation of each tasks and D&E activity
- ✓ verify and adjust the scientific and technical progress of the tasks
- ✓ proactively suggest improvements of the COST Action strategy
- ✓ participate at Dissemination & Exploitation activities
- ✓ communicate with the task members, invite foreign researchers & specialists relevant for their task and guarantee with the DEB an effective dissemination of each Task/Working Group.

The MC and EB will meet physically at least once per year, in case of extraordinary issues, it may also reach consensus by electronic communication. To ensure a simple as possible but effective and decisive management, also the EB will meet during this time and report to the MC about the Action's progress.

3.3. Network as a whole

Many researchers of the former related Action TD0906 will probably join the Action **ENBA** as such multidisciplinary cooperation is essential to execute their multidisciplinary work and achieve tangible progress in the field.
With the multilingual website and dedicated campaigns about the forthcoming Action and R&T objectives, **ENBA** will spread geographically and inform & invite researchers and companies from IPCs to join and use the available infrastructure/funding. Furthermore, with the websites **ENBA** also aims to give locals, school children and limited English-speaking people the possibility to be informed about the topic of bioadhesion and its technological potential.
Additionally, **ENBA** will invite international researchers and companies from IPCs such as Australia, Japan, Republic of Korea, New Zealand, USA and Russia working in the field of bioadhesion, to attend ENBA meetings and conferences, contribute in the Training Schools, participate on the technological set-up and implementation in WG 1 & 2 and accept STMS to their labs for formally approved IPC Institutions. Their experience and knowledge will be hugely beneficial to enhance European progress in bioadhesion research, understanding and reproducing the basic bonding mechanisms and principles involved.

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu