West Pomeranian
University of Technology
Szczecin

Bioimmobilisation - towards applied biotechnology for industrial applications

WNoŻiR

Faculty of Food Sciences and Fisheries

Center of Bioimmobilisation

and Innovative Packaging Materials

Chair of Food Packaging and Biopolymers

CBiMO

The West Pomeranian University of Technology officially was created on 1 January 2009. Bringing a new university into existence by joining two universities (Agricultural Academy in Szczecin and Szczecin University of Technology), besides enriching its teaching programme with new fields of study and specializations, creates a possibility of further, faster progress of new technologies in technical and natural sciences.

The West Pomeranian University of Technology (WPUT) has a chance to make use of an effect of synergy which originated from joining two well-known universities. Around 13 000 full-time and extramural students study in numerous facilities under the tutelage of over 1 100 academic teachers (including almost 280 professors and assistant professors). There are ten faculties at WPUT specializing in 44 fields of study:

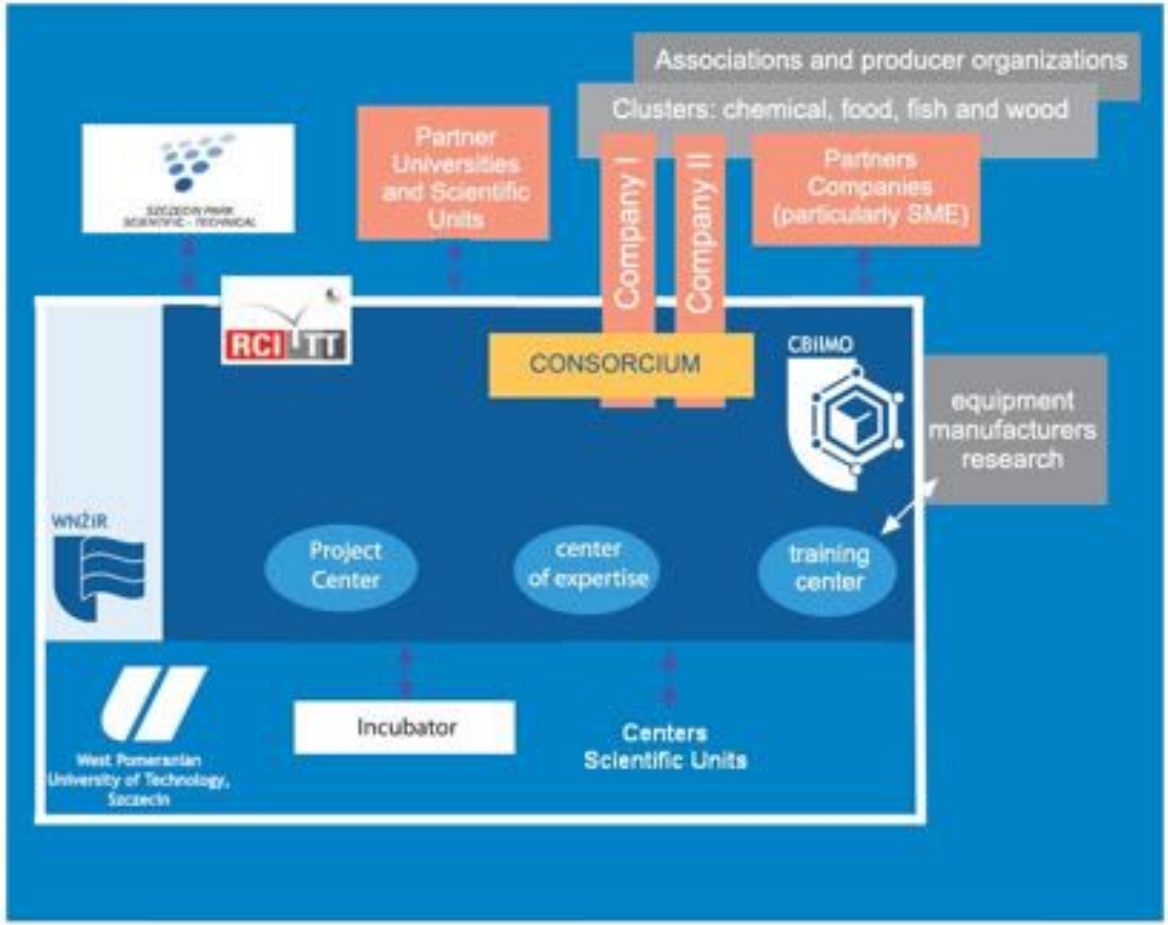
Faculty of Biotechnology and Animal Husbandry
Faculty of Civil Engineering and Architecture
Faculty of Economics
Faculty of Electrical Engineering
Faculty of Computer Science and Information Technology
Faculty of Mechanical Engineering and Mechatronics
Faculty of Environmental Engineering and Agriculture
Faculty of Food Sciences and Fisheries
Faculty of Maritime Technology
Faculty of Chemical Engineering

Center of Bioimmobilisation and Innovative Packaging Materials

New fields are constantly created as the answer to changing economic conditions and needs of the labour market..

The creation of the West Pomeranian University of Technology consolidated research teams dealing with: engineering, environmental protection, renewable energy, bio- and nanotechnologies, polymers, economics and industry and agriculture technologies. WPUT has powers to confer the PhD degree in 17 specializations and the degree of assistant professor in 9 fields.

CBIMO structure and international collaboration



www.cbimo.zut.edu.pl

Scientific activities of CBIMO

Immobilisation of living cells and microorganisms — P1

Immobilisation of bioactive substances — P2

Biodegradable packaging materials — P3

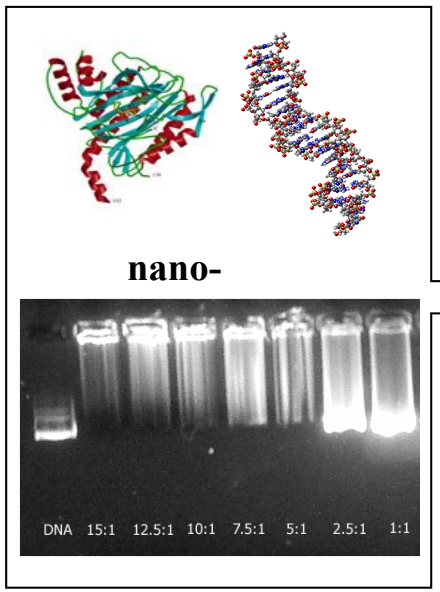
Novel Packaging methods and technologies — P4

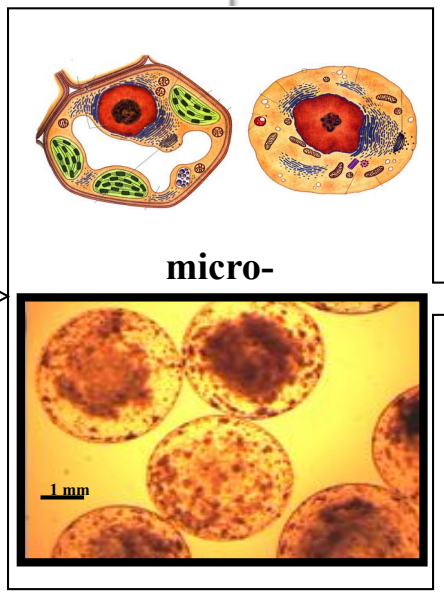
Biommobilisation

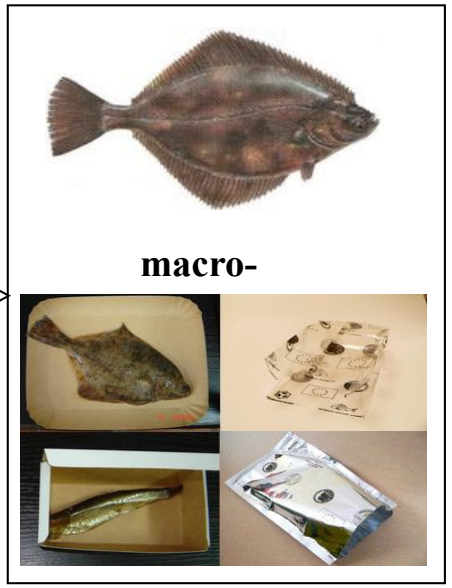
Innovative Packaging Materials

Main research topics and technologies

CBIMO







West Pomeranian University of Technology Szczecin

Center of Bioimmobilisation and Innovative Packaging Materials

Center of Bioimmobilisation and Advanced Packaging Materials (CBIMO)
is an interdisciplinary group at Faculty of Food Sciences and Fisheries (ZUT)

CBilMO research activities are mainly focused on three topics:

- **immobilisation and microencapsulation of bioactive substances and food-additives,**
- **biodegradable food-packaging materials (biodegradable plastics and cellulose based)**
- **properties of food-packaging materials (mechanical, gas-barrier, food contact etc.).**

Especially CBilMO has some expertise in:

- **novel microencapsulation systems based on natural and modified polymers,**
- **immobilization of living cells (animal&plant cells and bacteria, food-bioactive substances, taste and smell masking),**
- **biotechnological applications of immobilized bacteria for various processes,**
- **innovative biodegradable food packaging materials (cellulose, starch and PLA based)**
- **food and packaging interaction (long shelf-life studies - changes of texture and chemical composition during storage),**
- **characterization of food packaging materials (plastics and cellulose based) – various mechanical properties, oxygen, water vapor transmission rate and biodegradability measurements.**

Scientific projects of CBIMO

Projects funded under EU Funds:

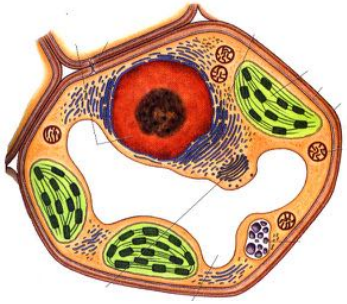
1. POIG.01.03.01-32-193/09-00„Health promoting food additives containing immobilized unsaturated fatty acids and pro biotic bacteria obtained by spray drying” (2010-2013)
2. POIG.01.01.02-00-074/09 "Biotechnological conversion of glycerol to polyols and dicarboxylic acids" (2010-2014)
3. POIG.04.01.00-14-084/09 "The application of polymeric materials on the surface layers of cardboard as a barrier to water vapor, water and fat " (2010-2011)
4. FP7-NMP-2007-SMALL - 7PR UE FLEXPAKRENEW "Design and development of an innovative ecoefficent low-substrate flexible paper packaging from renewable resources to replace petroleum based barrier films" (2008-2011)
5. COST FPS1003 Action "Impact of renewable materials in packaging for sustainability - development of renewable fibre and bio-based materials for new packaging applications" (2010-2013)

Projects funded by Polish Ministry of Science and Higher Education:

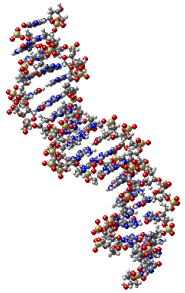
1. N305 1517 33 "Development a green method of surface water treatment from petroleum compounds using immobilized, environmental bacterial strains" (2007-2010)
2. N312 199135 "The application of bioimmobilisation process in technology for obtaining cyclodextrins from potato starch” (2008-2010)
3. N312 427937 „The processes of nano- emulsion and microencapsulation as a method of immobilization of functional food additives" (2009-2011)
4. N312 439937 „Continuous production of bacteriocins using the waste products of food industry" 2009-2011)
5. N312 334439 "Innovative methods for obtaining a composite film of poly(lactic acid) for food packaging with improved barrier properties" (2010-2012)
6. N508 592139 "Hydrofobisation of starch using fatty acids in the direction of receipt of the substrates for modifying cellulose packaging for food" (2010-2012

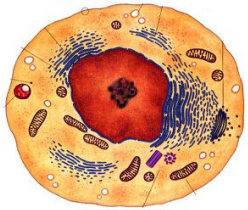
Proecological technologies used for immobilization of different bioactive components

Substrates: biopolymers and their chemical derivatives
Environment: aqueous
Process conditions: similar to physiological (pH, temperature, ionic strength)

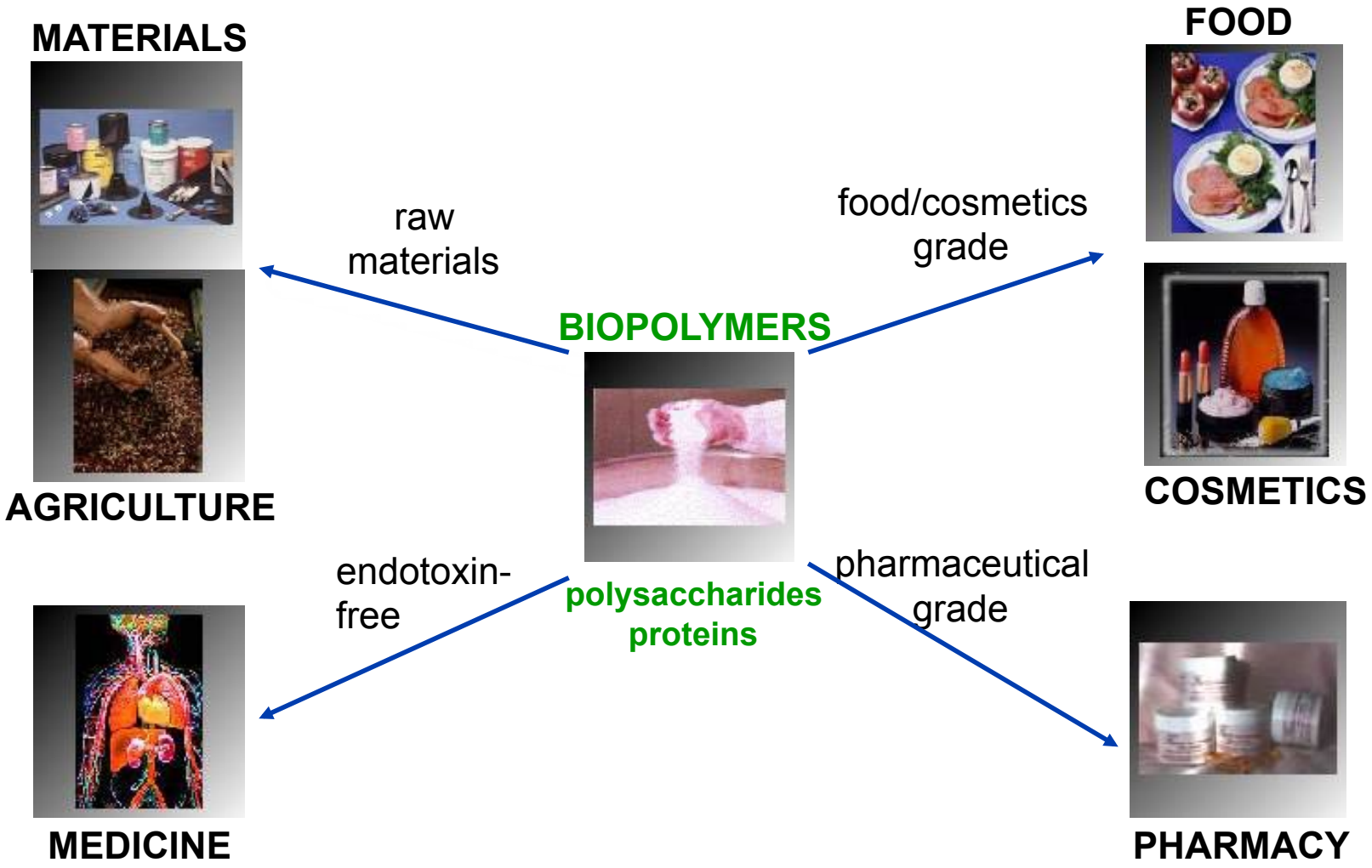


nano- → **micro-** → **macro-**





Potential Applications of Biopolymeric Microcapsules

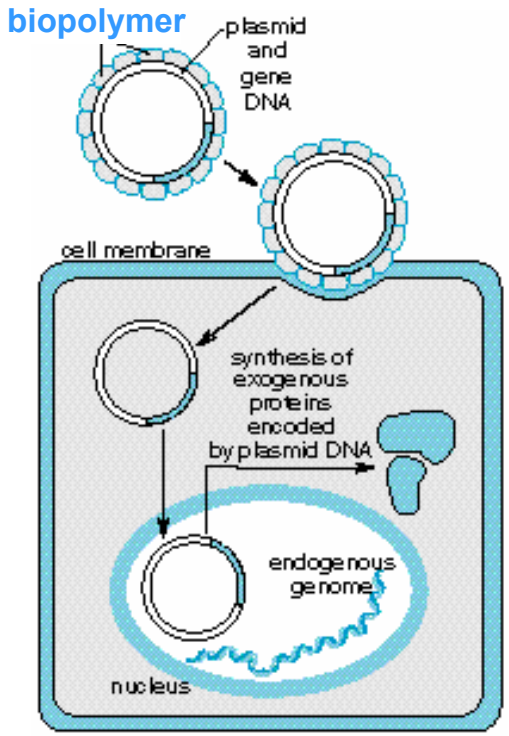


A. Bartkowiak, W. Brylak, T. Spychaj „Method of hydrogel microcapsule formation"

PL Patent Application P372100 (2004)

Nano-immobilization of bioactive substances (DNA, proteins...)

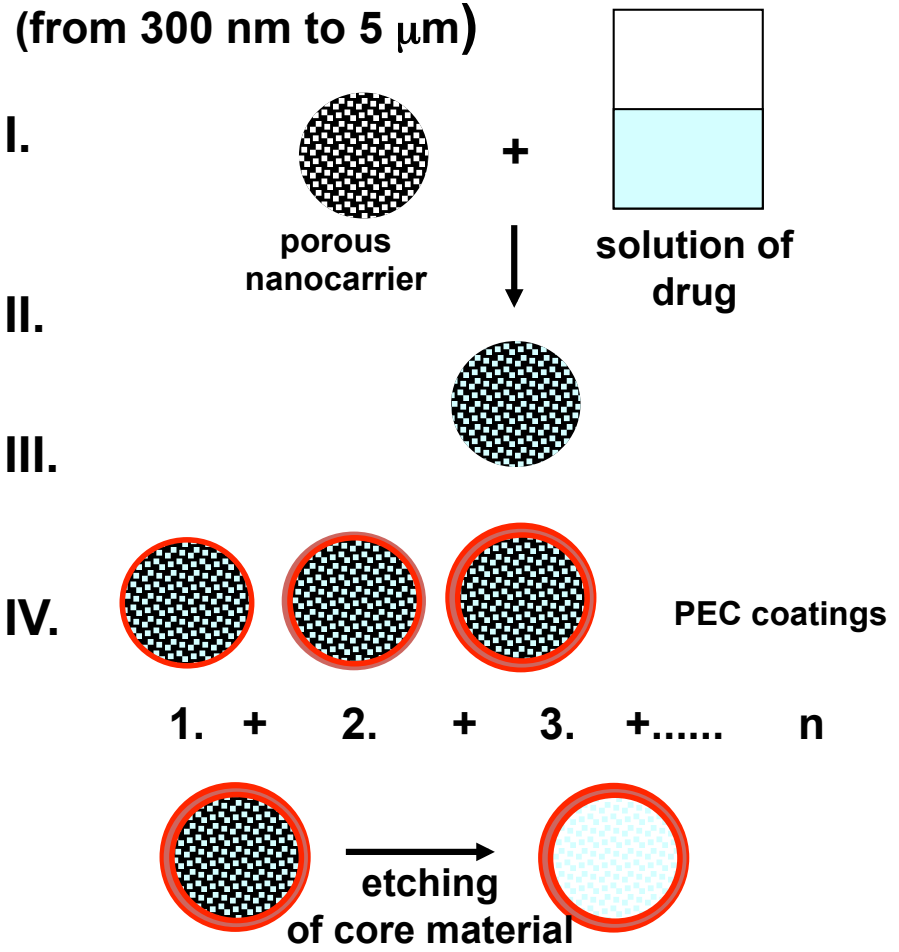
Polyelectrolyte intelligent complexes – gene therapy



Diego Delgado; M Angeles Solinís; Artur Bartkowiak; Ana del Pozo-Rodríguez; Alicia Rodríguez Gascón, New gene delivery system based on oligochitosan and solid lipid nanoparticles: 'in vitro' and 'in vivo' evaluation. European journal of pharmaceutical sciences : 2013;50(3-4):484-91.

Multilayer nano-capsules

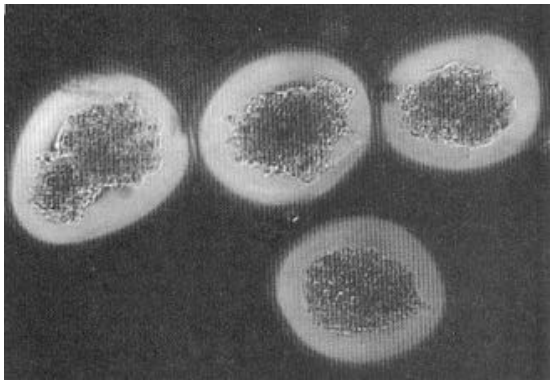
(from 300 nm to 5 μm)



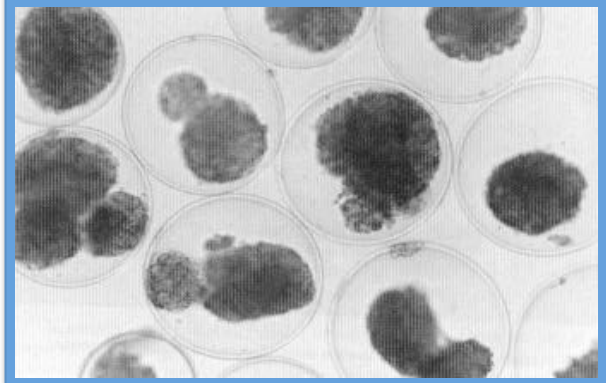
Selina OE, Belov Slu, Vlasova NN, Balysheva VI, Churin AI, Bartkoviak A, Sukhorukov GB, Markvicheva EA., Biodegradable microcapsules containing DNA for the new DNA vaccine design. Bioorg Khim. 2009 Jan-Feb;35(1):113-21.

Advatages of Microencapsulation Technologies

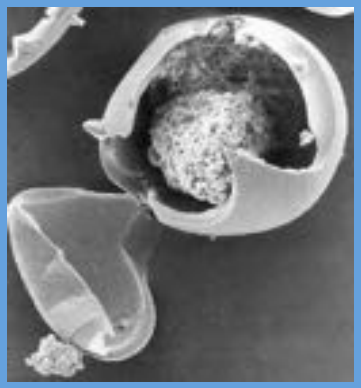
1. Various methods of formation



Photopolymerization



Polyelectrolyte complexes

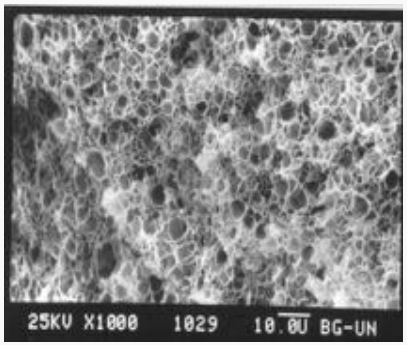


Surface precipitation

2. Tunable properties (mechanical, chemical and structural)

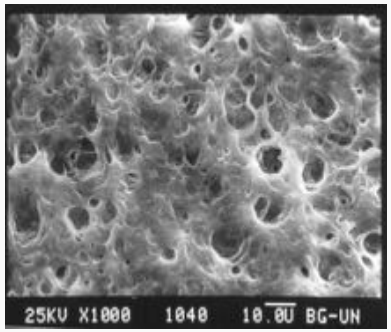
MEMBRANE POROSITY

LOW



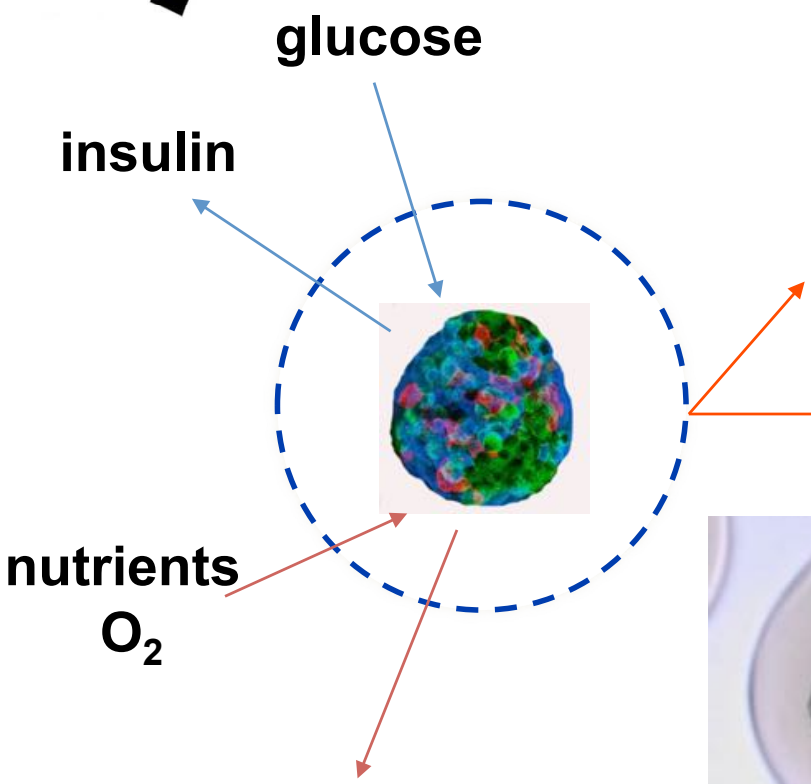
- high polymer concentration

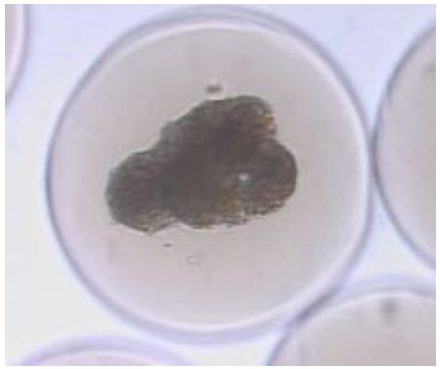
HIGH



- low polymer concentration

Principales of Bioartificial Organs
„Bioartificial Pancreas”





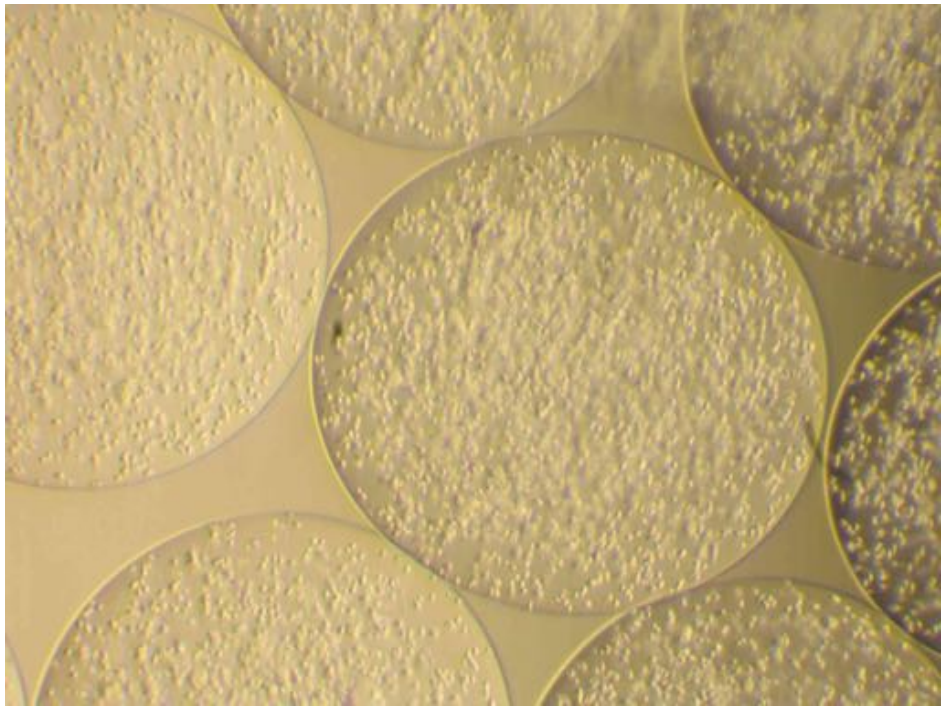
Rat Pancreatic Islets
Encapsulated in PEC microcapsules
(400 microns)

MOLAR MASS daltons	MOLECULES
16	oxygen
17	ammonia
44	carbon dioxide
60	urea
180	glucose
4000	C5a
5733	insulin
9000	C3a
13000	NGF
17000	IL-1b
51000	TNF
55000	factor X
64000	hemoglobin
66248	albumin
79000	C9
81000	transferrin
150000	IgG
160000	IgD
170000	C2, IgA
180000	leucocyte antigens
185000	C3
190000	(180000-210000)
247000	IgE
339000	catalase
950000	fibrinogen
	IgM

Evaluation of viability of beta-cells immobilized in alginate microcapsules coated with modified oligosaccharides

COOPERATIONAL INSTITUTION

dr. P. (Paul) de Vos
University of Groningen
Faculty of Medical Sciences
Groningen
The Netherlands



Capsules size 650 µm

M. Soból M, A. Bartkowiak, B. de Haan, P. de Vos, Cytotoxicity study of novel water-soluble chitosan derivatives applied as membrane material of alginate microcapsules, Journal of Biomedical Materials Research Part A, 101A(7), (2013), 1907-1914.

Potential applications:

Development of "tailored made" encapsulation system for various cell therapy methods

New 3D cell models for in vitro testing

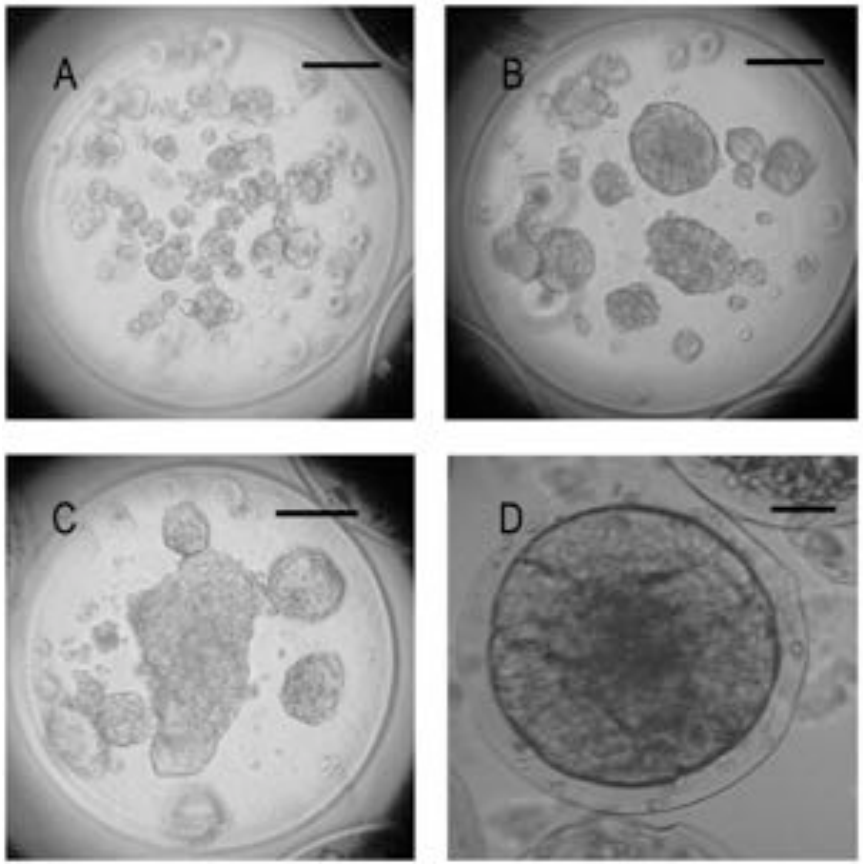
COOPERATIONAL INSTITUTION

Prof. Elena A. Markvicheva PhD, DSc

Polymers for Biology Laboratory,

Shemyakin and Ovchinnikov Institute of Bioorganic Chemistry of Russian Academy of Sciences,

Moscow, Russia



D.S. Zaytseva-Zotova, O.O. Udartseva, E.R. Andreeva, A. Bartkowiak, L.N. Bezdetnaya, F. Guillemin, J-L. Goergen, E.A. Markvicheva, 2011, Polyelectrolyte microcapsules with entrapped multicellular tumor spheroids as a novel tool to study the effects of photodynamic therapy J Biomed Mater Res B Appl Biomater. 2011; 97(2), 255-62.

.

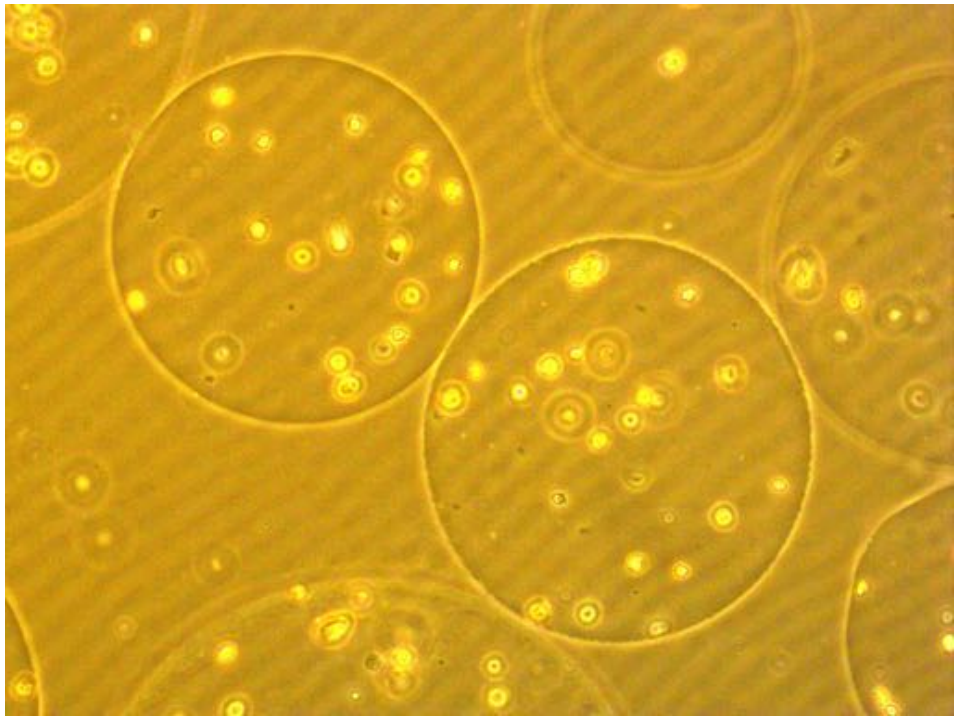
Potential application:

Evaluation in vitro of different methods of cancer treatment using 3D model

Encapsulation of mononuclear blood cells and stem cells

COOPERATIONAL INSTITUTION

Prof. Bogusław Machaliński MD, PhD, DSc
Head of Department of General Pathology
Pomeranian Medical University
Szczecin, Poland

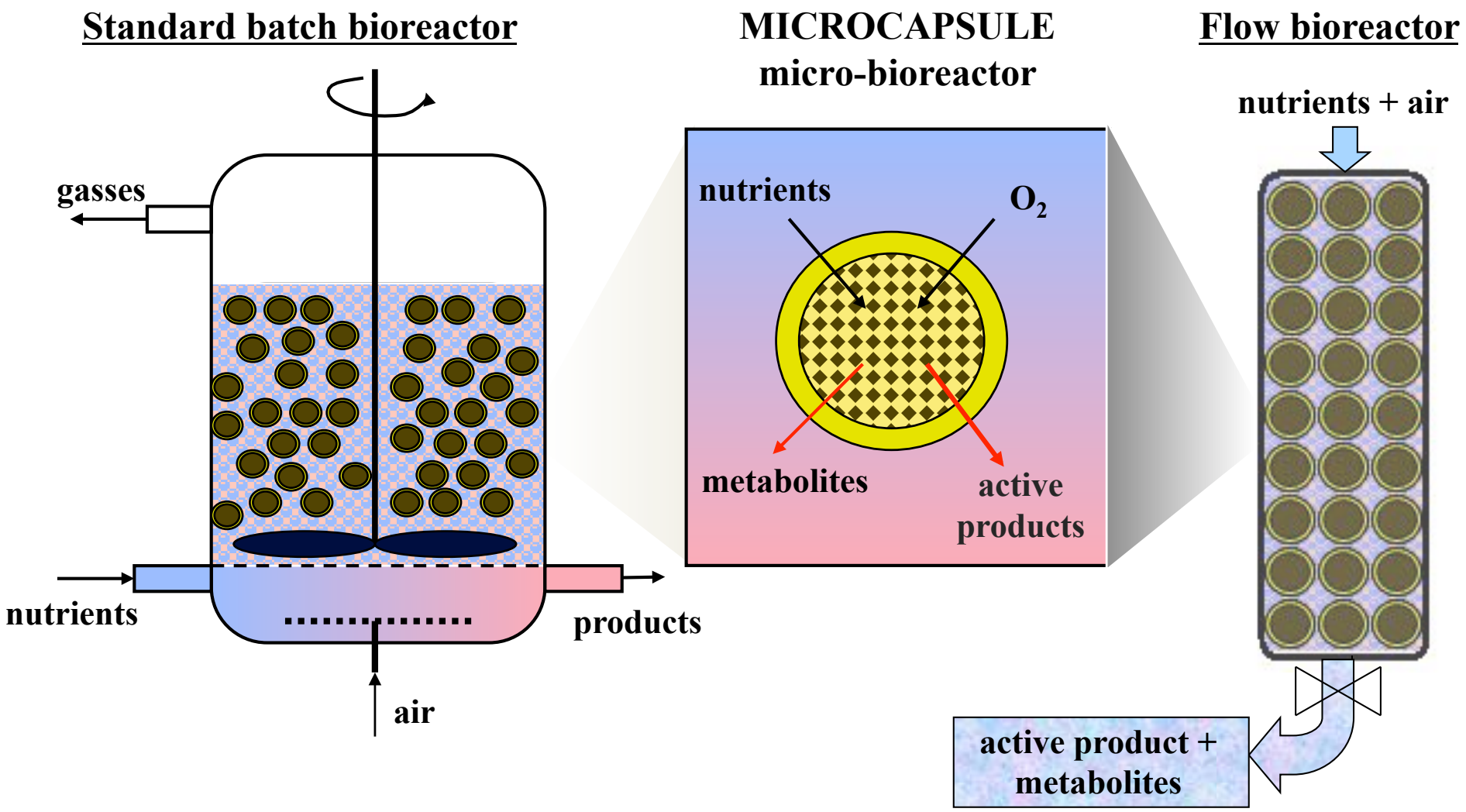


Capsules size 250 µm

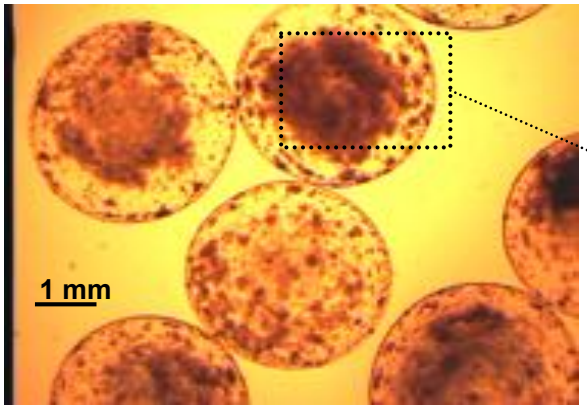
Potential application:

Production both in vivo / in vitro of specific bioactive molecules

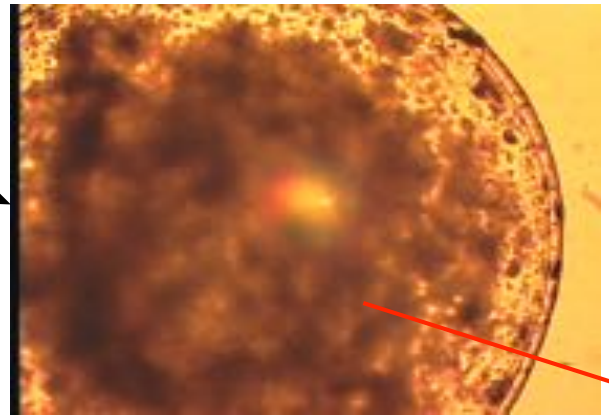
Biotechnological processes – from batch towards continuous



Immobilization of CHO cells using binary polysaccharidic capsules



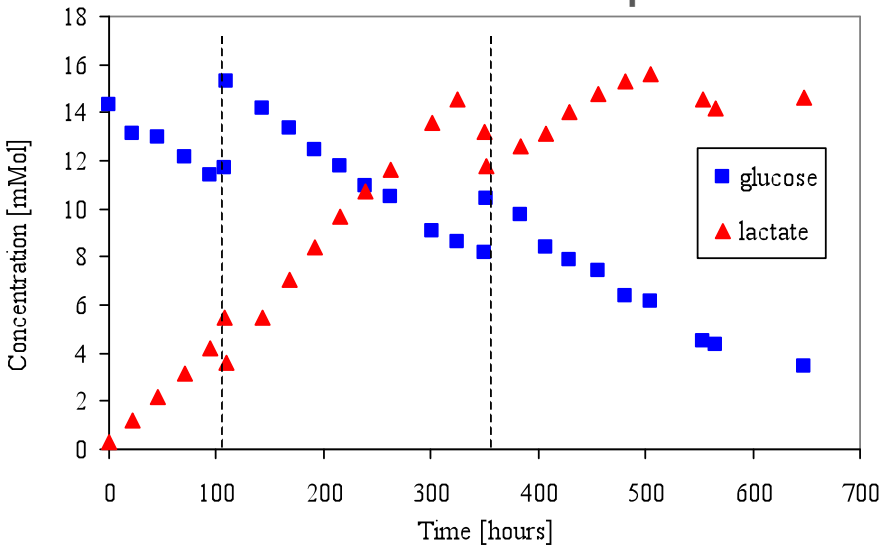
PEC capsules after 25 days in bioreactor



CHO *SSF3*
(Novartis, CH)

glycoprotein SC (66 kDa)
constituent of human immunoglobulin A

Monitoring of viability of CHO cells immobilized in microcapsules



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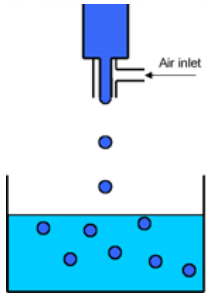
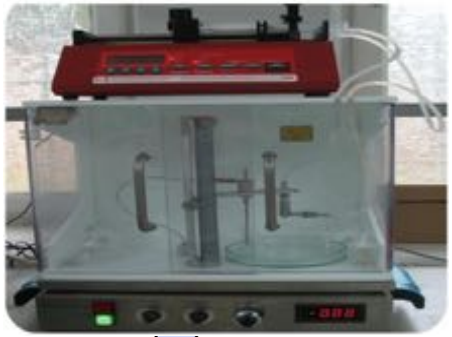
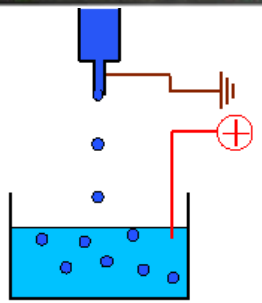
Cell encapsulation methods

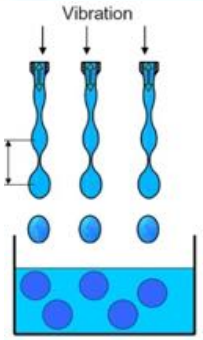


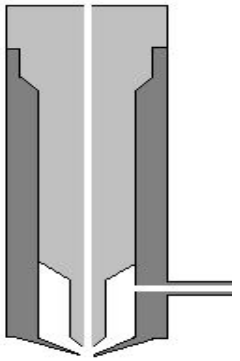
Air flow



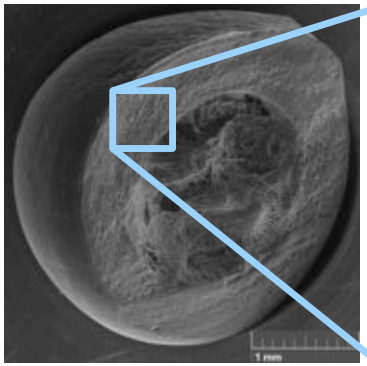


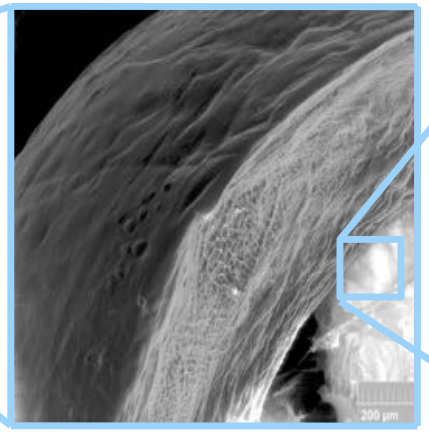
Electrostatic

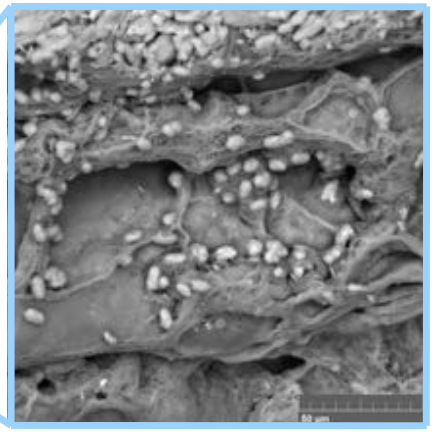




Laminar jet break-up with additional co-axial nozzle







Capsules size 2,5mm

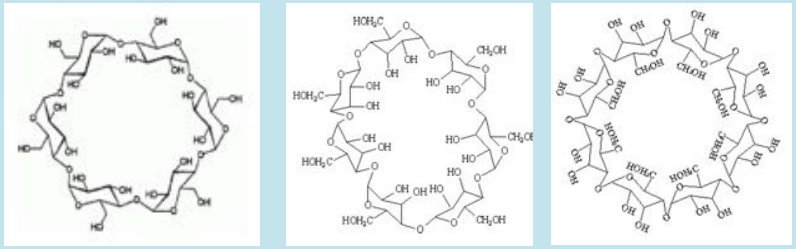
Bacteria cell encapsulated in novel stable microcapsules

European Patent submission EP13461563

Continuous production of cyclodextrins by immobilized microorganisms

W. Krawczyńska, A. Bartkowiak (e-mail: wkrawczynska@zut.edu.pl)

1. Selection of microorganisms and immobilisation systems



Types of cyclodextrins: α-CD, β-CD, γ-CD .

***Bacillus sp.* i *Bacillus pseudofirmus* in starch solution (phenolphtalein as indicator)**

2. Continuous production of selected cyclodextrins using immobilized bacteria

Microcapsules with immobilized bacteria which convert starch into the cyclodextrin

3. Stable complexes with bioactive substances – food additives

This work is supported by Polish Ministry of Science and Higher Education - contract 1991/B/P01/2008/35 (2008-2010)

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INNOWACYJNA GOSPODARKA
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO

„Biotechnological conversion of glycerol to polyols and dicarboxylic acids”

PO IG 01.01.02-00-074/09 (2010-2014)

Isolation and screening of microorganisms

Optimization of culture medium and fermentation conditions

Immobilization of microorganisms

Center of Bioimmobilisat and Innovative Packaging Materials

Fermentation process

Separation and purification of particular metabolites

Valorization of purified metabolites for chemical products

Research partners:

Uniwersytet Przyrodniczy w Poznaniu

West Pomeranian Uniwersity of Technology Szczecin

http://www.zielonachemia.org.pl

Potential industrail recipients:

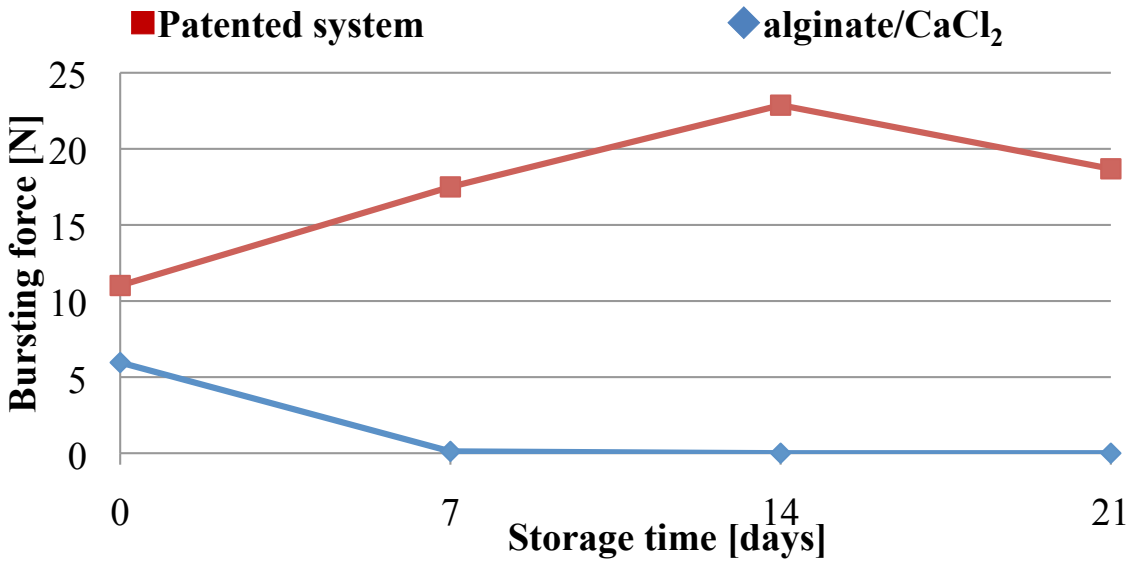
ZAK Zakłady Azotowe Kędzierzyn SA

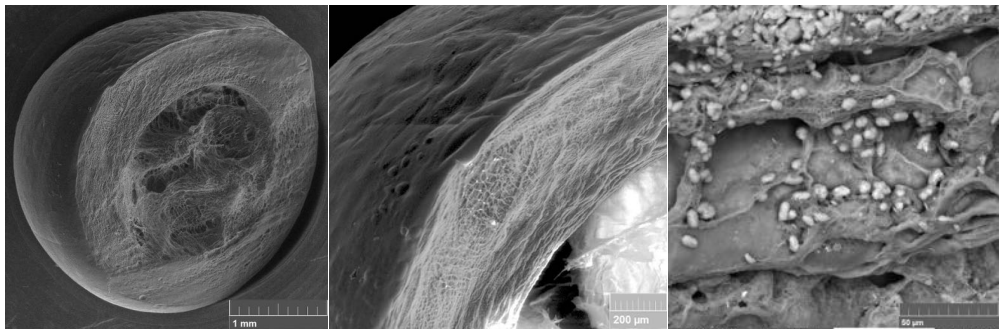
Ciech Zachem

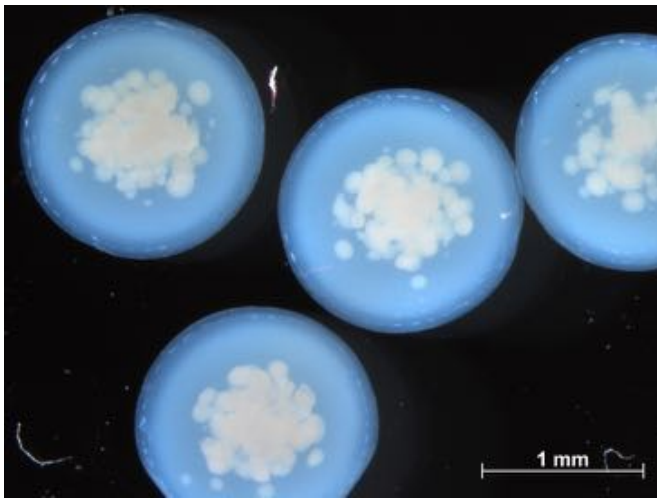
skotan

NEW system for bioimmobilisation of living cells for biotechnological processes

Mechanical stability of new encapsulation system in culture medium:

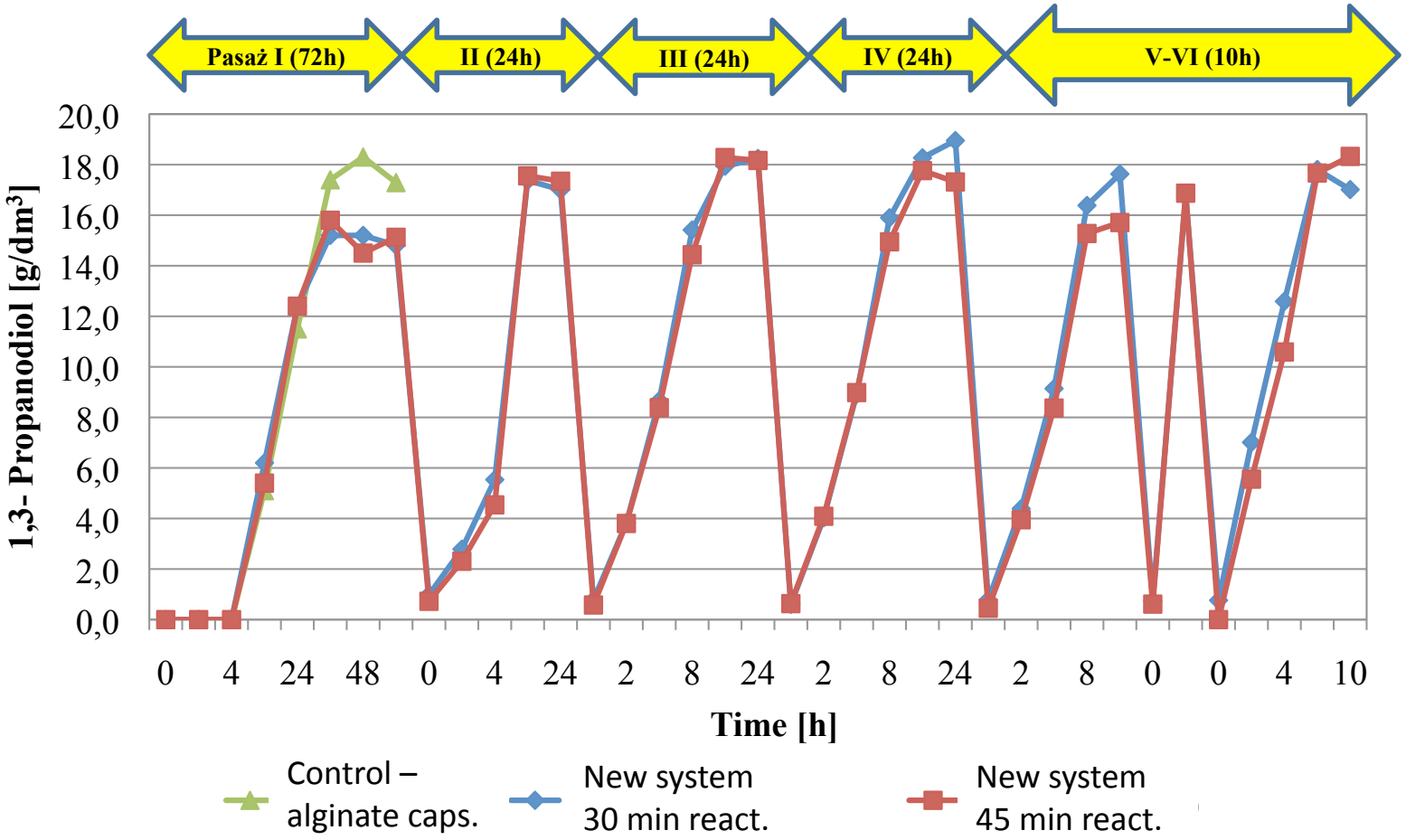


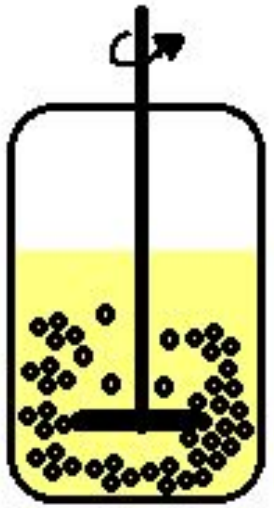


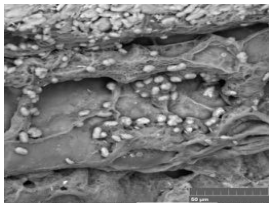


NEW patent applications:
M. Soból, A. Bartkowiak, A process for preparing microcapsules – PL P.405101 i EP13461563 (2013).

Batch bioconversion of glycerol to 1,3- propanodiolu (1,3-PD) via immobilised C. freundii



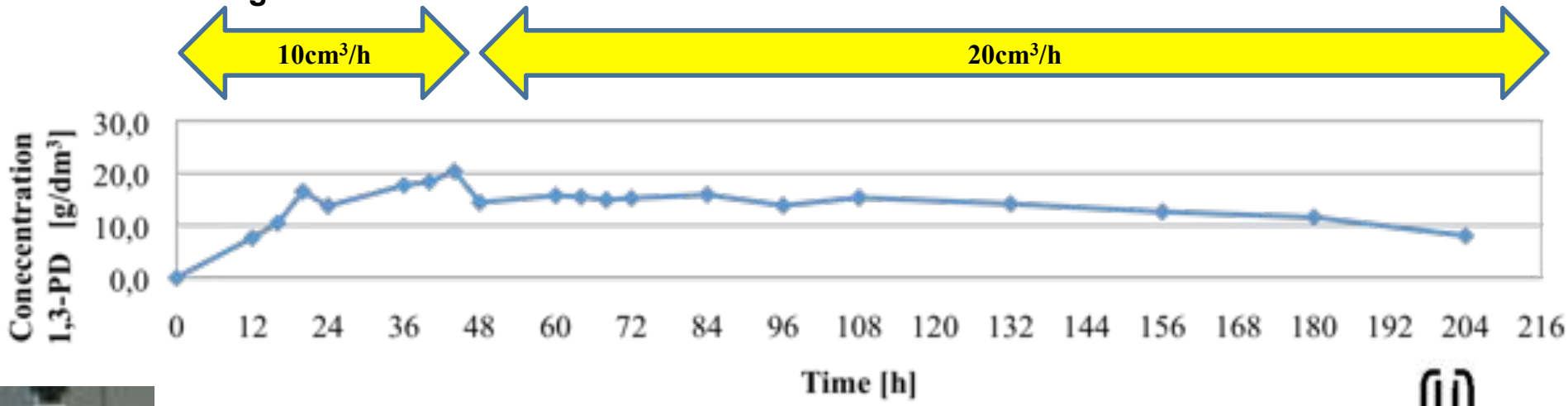


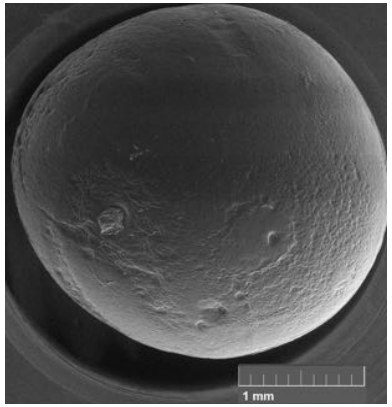


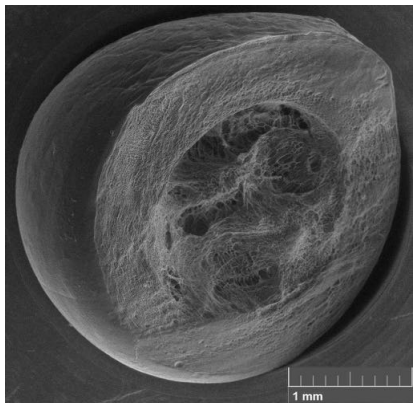
NEW patent applications:
M. Soból, A. Bartkowiak, A process for preparing microcapsules – PL P.405101 i EP13461563 (2013).

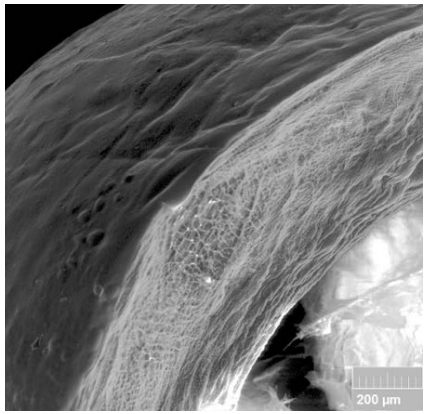
Continious bioconversion of glycerol to 1,3- propanodiolu (1,3-PD) via immobilised *C. freundii*

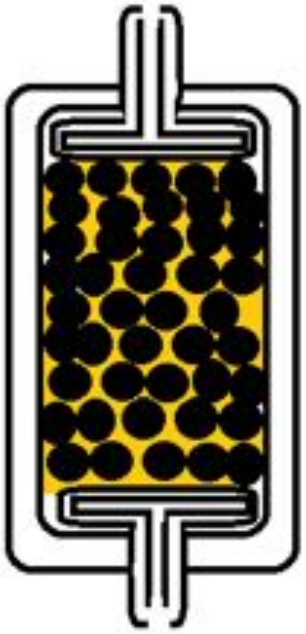
Flow through the column











NEW patent applications:
M. Soból, A. Bartkowiak, A process for preparing microcapsules – PL P.405101 i EP13461563 (2013).

INNOWACYJNA GOSPODARKA
NARODOWA STRATEGIA SPÓJNOŚCI

Center of Bioimmobilisation and Innovative Packaging Materials
ProBioKap

UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO

„Health promoting food additives containing immobilized unsaturated fatty acids and pro biotic bacteria obtained by spray drying" - ProBioKap

POIG.01.03.01-32-193/09-00 (2010-2013)

Probiotic bacterial culture

Natural antioxidants

Emulsion
(carrier/oil/antioxidants/ bacteria)

Spray drying

Products

Industry partners

West Pomeranian University of Technology Szczecin

Center of Bioimmobilisation and Innovative Packaging Materials

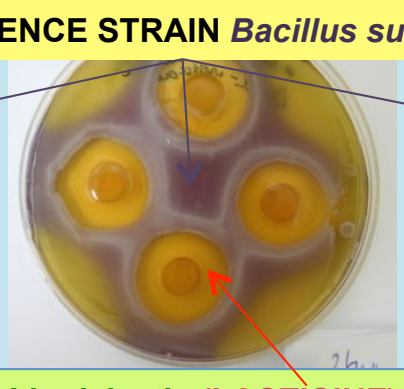
Continuous production of bacteriocins by immobilized microorganisms

K. Sobecka, A. Bartkowiak (e-mail: ksobecka@zut.edu.pl)

1. Selection of microorganism and immobilisation systems

REFERENCE STRAIN *Bacillus subtilis*

***E. durans* (ENTEROCINE)**

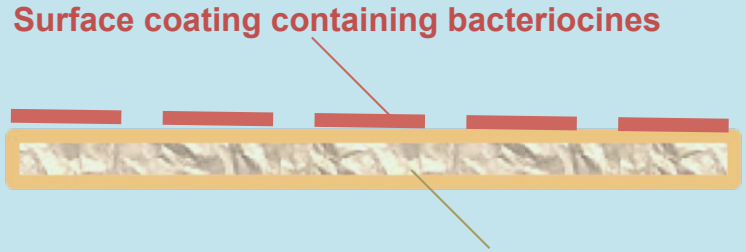


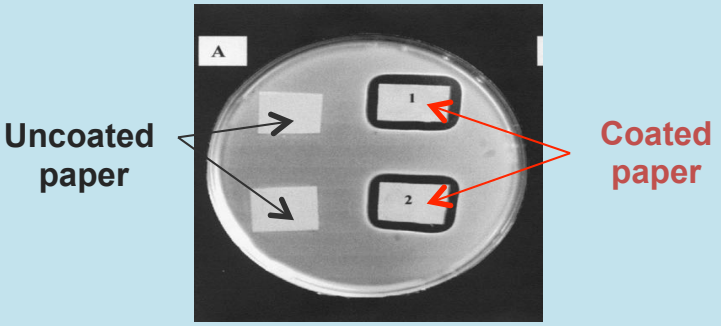
***Lb. d. lactis* (LACTICINE)**

***Lc. lactis* (NISIN)**

2. Contionious production of bacteriocine solution using flow bioreactor

3. Bioactive coatings of food packaging materials





JSI Z 2801:2000 „Antimicrobial products - test of antimicrobial activity and efficiacy”

This work is supported by Polish Ministry of Science and Higher Education - contract 1517/B/P01/2009/33 (2009-2011)

West Pomeranian University of Technology Szczecin

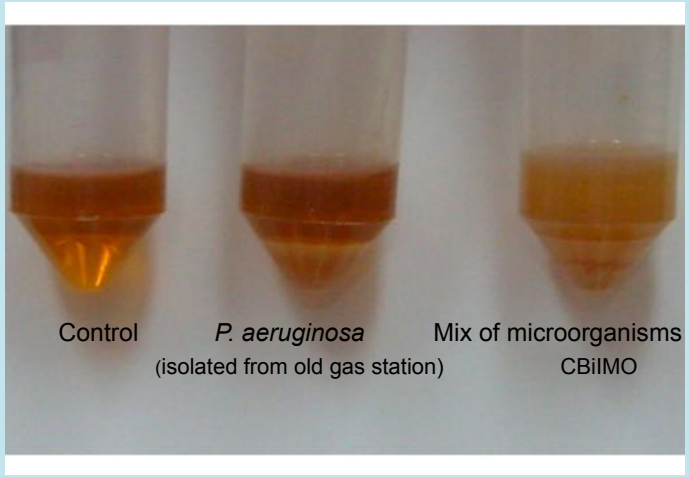
Center of Bioimmobilisation and Innovative Packaging Materials

Bio-systems for direct purification of water from petroleum hydrocarbons

M. Mizielińska, A. Bartkowiak (e-mail: mmizielinska@zut.edu.pl)

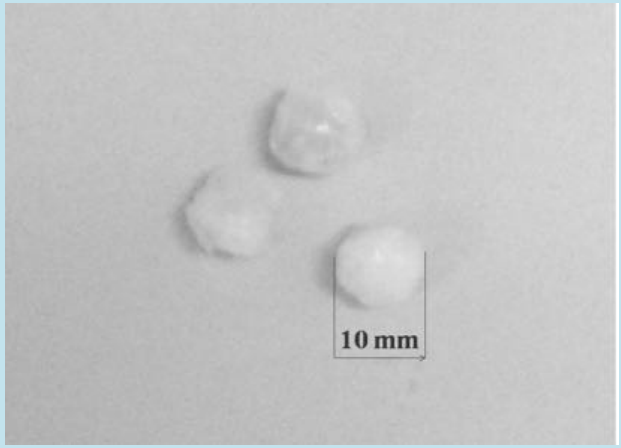
Novel immobilization systems facilitate both adsorption of hydrocarbons and growth of immobilized biomass at high degradation rate.

1. Selection of microorganisms



Diesel oil after 9 weeks of incubation at 37 °C (group of 8 isolated strains)

2. Selection of immobilisation/oil adsorption system



Biopolymeric microorganism carriers containing natural based oil-adsorber - final adsorption capacity of 5-10 g of oil/1 g of adsorber.

3. Proof of concept (1 + 2) using model systems (water + diesel oil)

This work is supported by Polish Ministry of Science and Higher Education - contract 1517/B/P01/2007/33 (2008-2010)

West Pomeranian University of Technology Szczecin

Center of Bioimmobilisation and Innovative Packaging Materials

BIO-immobilisation in microalgae production

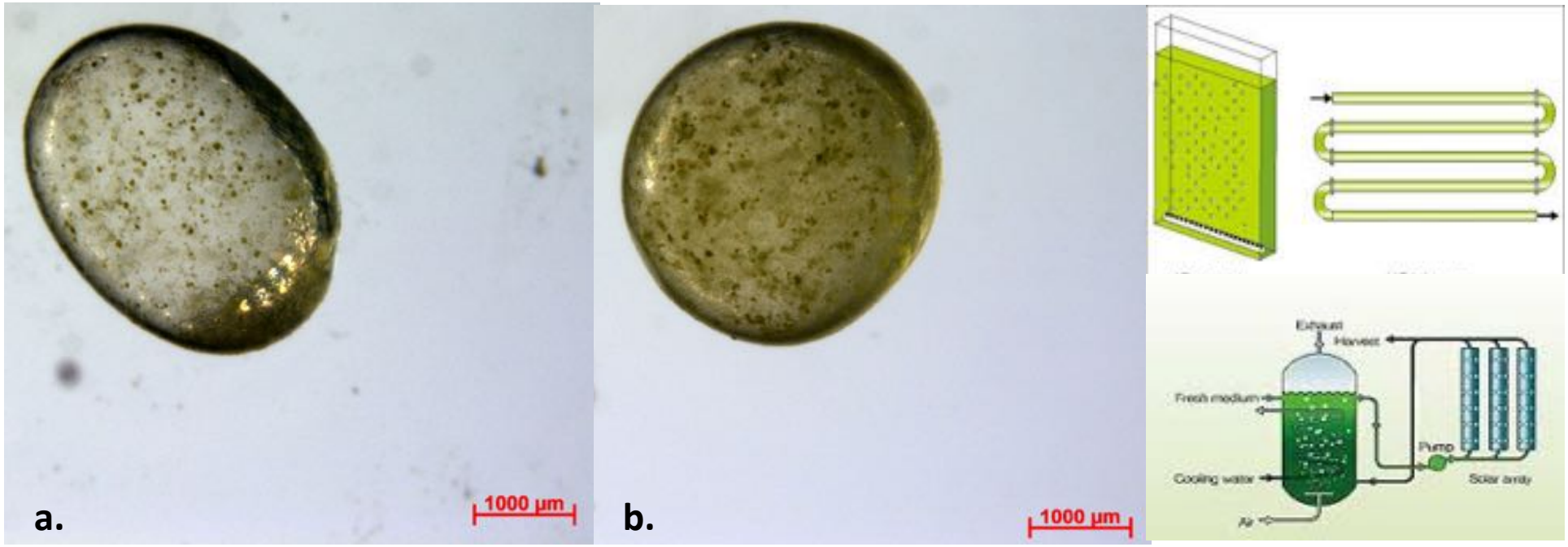
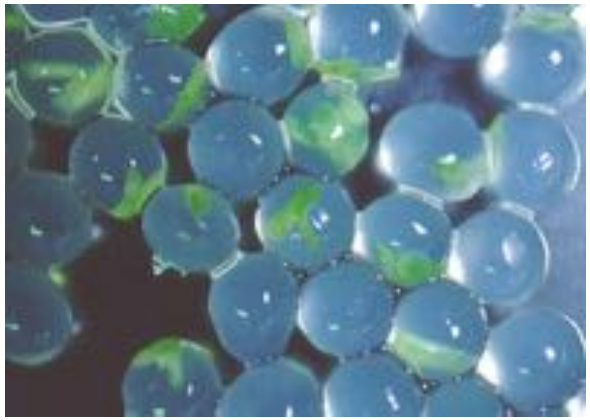


Fig. Growth of microalgae (*Chlorella*) in hydrogel capsules: time a) 0 h, b) 72 h

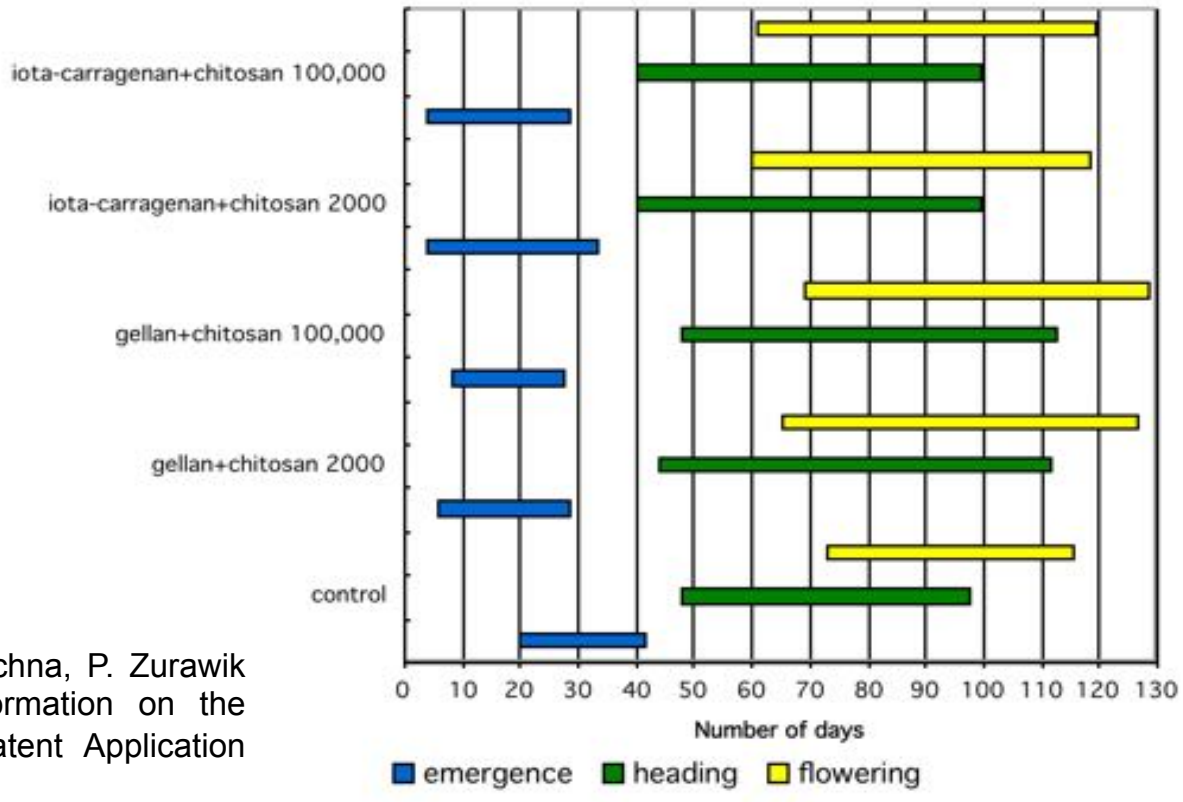
BIO-immobilisation in micro- and macroscale in plant production

Somatic embryos

– in vitro



Coating of plant organs



A. Bartkowiak, L. Startek, P. Slachna, P. Zurawik "Method of hydrogel coating formation on the surface of plant organs" PL Patent Application P359797 (2003)

Modern infrastructure

From July 2011 we are located in the new building of Center of Bioimmobilisation and Innovative Packaging Materials (more than 2000 m^2)

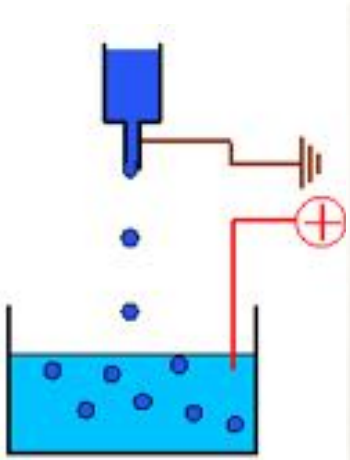
created 2008 (2 UNIV + 2 IND)
Large infrastructure project 2009-2011
(EU SF 2007-2013)
4.5 mEuro

Various microencapsulation techniques

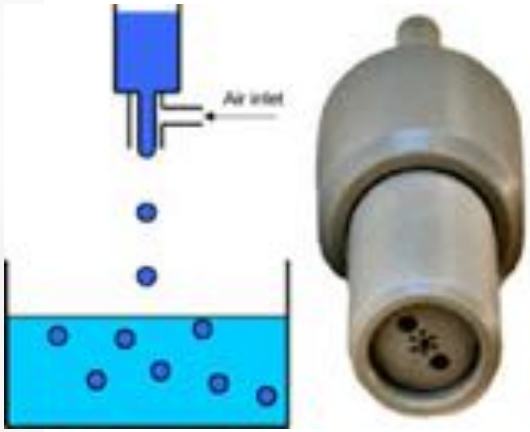
Lab Spray Dryer
BUCHI B-290 ADVANCED

Pilot Spray Dryer
Anhydro MicraSpray 150

Mastersizer 2000 - size analyzer
Malvern (UK)



Var V1 (Nisco, CH) -
electrostatic capsule generator



Var J1 (Nisco, CH) -
fluidized capsule generator

Var D Generation II (Nisco, CH) -
electromagnetically driven generator

Chemical modification of biopolymers, purification and characterization including emulsion based methods

Ultrafiltration systems
Labscale TFF "Pelicon TFF"

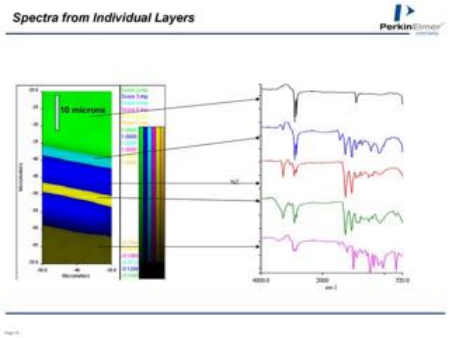
HPLC-GPC "Smartline" (Knauer, G)

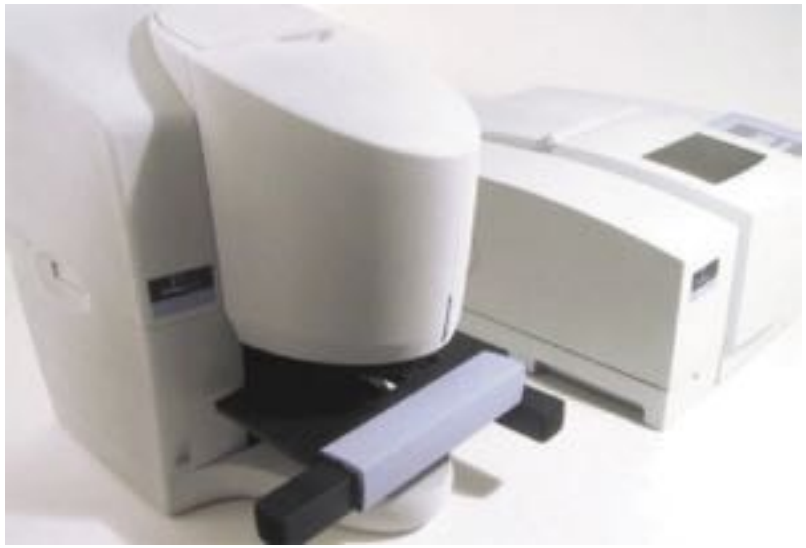
US generators (400 and 1000W) with flow cells - Hielscher (D)

IKA® magic LAB®

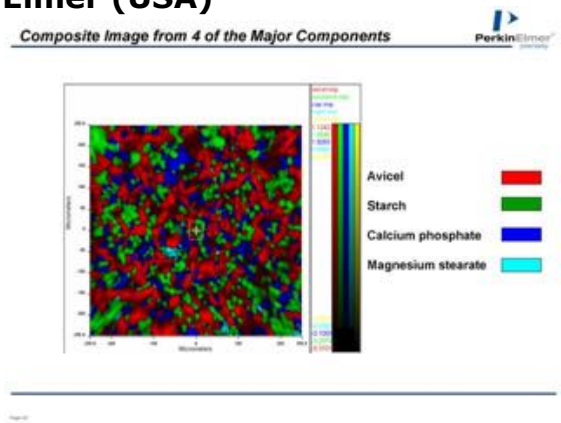
Chemical characterization by various spectroscopic method

FTIR spectrometer + microscope
Spectrum 100 + Spectrum Spotlight 300
PerkinElmer (USA)





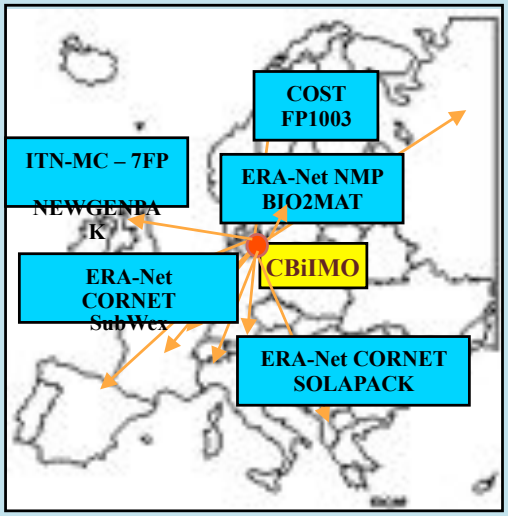
Raman spectrometer - chemical scan of surfaces
RamanStation 400 -
PerkinElmer (USA)



CBIMO as a partner: interdisciplinary + creative + operative + ……

Interdisciplinary group

Applied oriented projects



Modern infrastructure

created 2008 (2 UNIV + 2 IND)
Large infrastructure project 2009-2011
(EU SF 2007-2013)
4.5 mEuro

Expertise in novel techniques and methods

- innovative packaging – biodegradable packaging materials, bioactive packaging, MAP food packaging / gas barrier properties
- biopolymers – biosynthesis, chemical modification, purification and application,
- characterization of materials (surface and interfacial, emulsion, mechanical, biodegradation);
- various microencapsulation techniques – food additives, bioprocessing including food waste conversion)

Center of Bioimmobilisation and Innovative Packaging Materials CBIMO
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