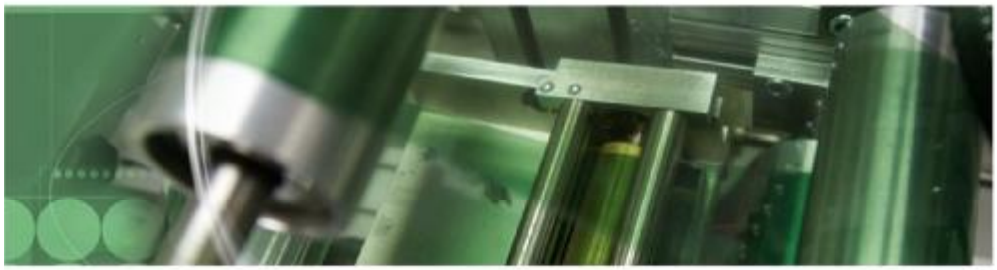


Building a better future with tailor-made plastics

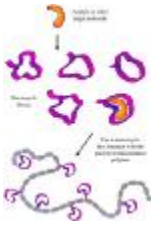
FUNMAT
Annual meeting, May 22-23, 2012

Carl-Eric Wilén, Professor
Head of laboratory
Laboratory of Polymer Technology
Åbo Akademi University
Biskopsgatan 8
FIN-20500 Åbo, Finland
Phone: + 358-(0)2-2154308
Mobile phone +358-(0)50-4096406
Fax: +358-(0)2-2154866
Email:cwilen abo.fi

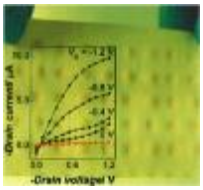
What are the common Challenges, Trends and Technologies that will shape our future?

- Challenges
  - › Global warming
  - › Shortages of energy, food and natural resources
  - › Sustainable development
  - › Global interdependencies (e.g. economical, environmental and legal)
  - › Disparity between rich and poor
- Trends
  - › New renewable energy (e.g. solar, wind and fuel cells)
  - › Nanotechnology
  - › Biocatalysis (organic replaces petrochemicals)
  - › Wireless connectivity (more device to device communication)
  - › New electronics (RFID, sensors embedded in infrastructure and devices)
- Technologies
  - › Diversified Sensors
  - › Human ingested sensors
  - › Online monitor of human health
  - › Quantum computing & communication

Overview of Research Activities



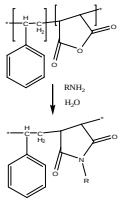
P. Sund et al. submitted to Macromolecules



N. Kaihovirta et al. Advanced Functional Materials (2010), 20(16), 2605-2610

R+D highlight Specialchem

T. Vestberg et al. J. Polym. Sci, Part A: Polym Chem. (2010), 48(2), 351-358.



M. Ahokas et al Organic Coatings (2011), 71(3), 290-294.

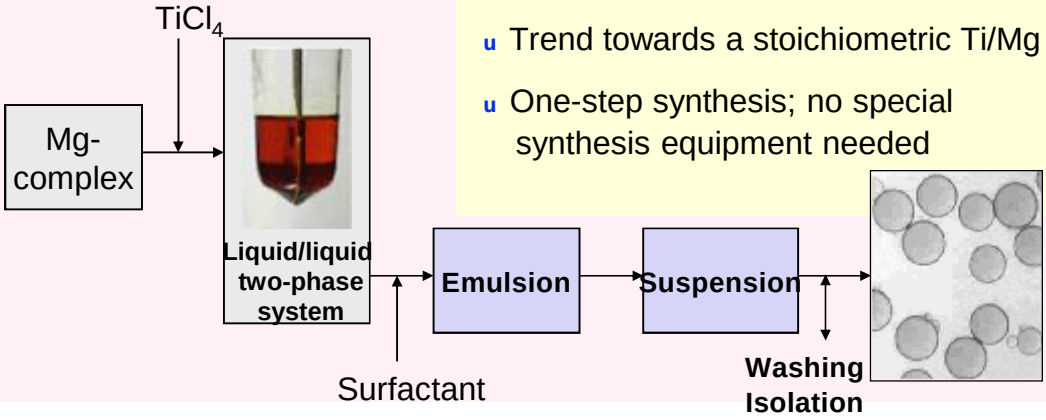
M. Aubert et al. Polymer Degradation and Stability, (2011), 96(3), 328-333

R+D highlight ACS

S. Inkinen, et al. *Biomacromolecules* (2011), 12 (3), 523–532.

1. Sirius Catalyst Technology Platform

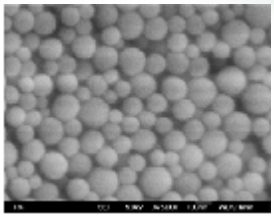
- Perfect homogeneity achieved in solution
- No further activation step necessary
- Trend towards a stoichiometric Ti/Mg ratio
- One-step synthesis; no special synthesis equipment needed



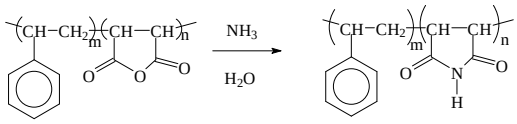
Torvald Vestberg (ongoing PhD thesis):

1. T. Vestberg, M. Parkinson, I. Fonseca, C-E. Wilén "Production of heterophasic PP"
2. T. Vestberg, M. Parkinson, I Fonseca, C-E. Wilén, DOI 10.1002/app355886.
3. T. Vestberg, P. Denifl, M. Parkinson, C-E. Wilén J. of Polym. Sci., Part A: Polym. Chem. (2010), 48(2), 351-358.
4. T. Vestberg, P. Denifl ; C-E. Wilén, J. of Appl Polym Science (2008), 110(4), 2021-2029.

2. Organic mineral hybrid systems



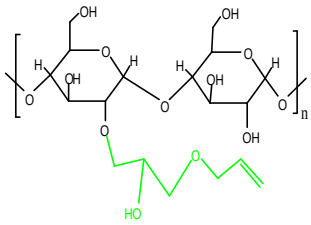
- High Tg's, between 165°C and 205°C
  - No film-forming properties
- Unique spherical particles, 50 -150 nm
- Relative high solids and low viscosity
- **Synergies with various binders**
  - High coverage properties
  - Interaction and compatibility with other pigments (e.g. kaolin, $CaCO_3$)
- **Decrease of calendar pressure**
  - Reduced calendar sticking
  - Reduction of calendar-nip passages
- **Improvement of paper and print gloss**
  - Improved offset printability
  - Increase of IGT
  - Increase of wet pick
  - Increase of micro porosity
  - Quick offset water drainage
  - Better packing of the pigments
  - Improved smoothness
  - Decrease of mottling
  - Improvement of thermal resistance



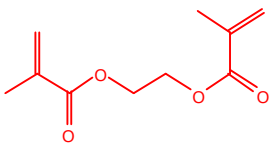
Mia Ahoka´s doctoral thesis 2011

1. Ahokas, M., Wilen, C-E. Progress in Organic Coatings (2011), 71(3), 290-294.
2. Ahokas, M., Wilen, C-E. Polymer Bulletin (2011), 66(4), 491-501.
3. Ahokas, M., Wilen, C-E. Progress in Organic Coatings (2009), 66(4), 377-381.
4. Koskinen, M. Wilen, C-E. Journal of Applied Polymer Science (2009), 112(3), 1265-1270.

2. Bio-Composites Based on Wood Fibers and Potato Starch Modified with Allylglycidyl Ether



+



ethylene glycol dimethacrylate

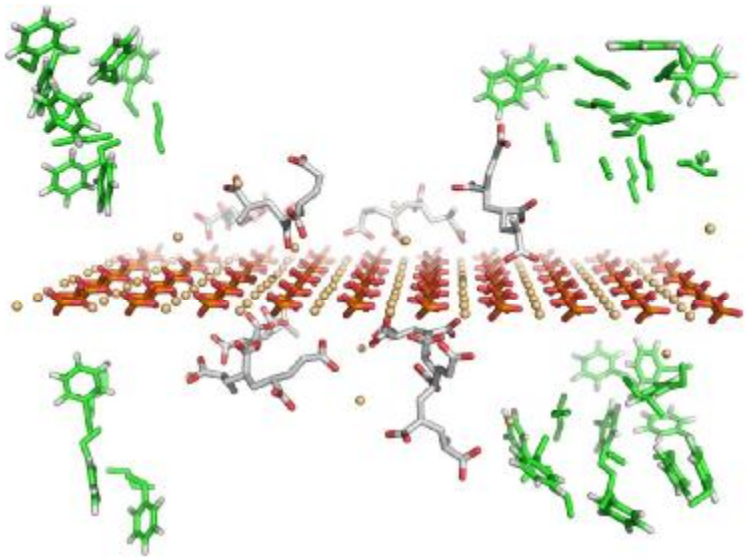
→ **Bio-Composite**

1. Benzoyl Peroxide
2. Wood fibre
3. 150°C hot compression

Jie Duanmu´s doctoral thesis 2011:

1. Duanmu, J., Gamstedt, E.K, Rosling, A. Starch/Stärke, 2007, 59, 523-532.
2. Duanmu, J., Gamstedt, E.K, Rosling, A. Composites Science and Technology, 2007, 67, 3090-3097.
3. Duanmu, J., Gamstedt, E.K, Andrey, P, Rosling, Composite A, 2010, 41, 1409-1418.
4. Duanmu J., Gamstedt E.K, Andrey P, Rosling A. Journal of Composite Materials, 2012 in press.

2. Optimal binders for paper coatings



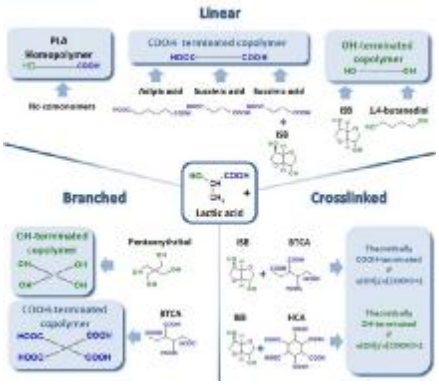
Small scale testing is ongoing in Industry

Green = Polymer binder
Red = Calcite surface
Grey = Dispersing agent

3. Biomaterials - Modification of the Properties of PLA

- Copolymerization
  - Possible both in ROP and step-growth polymerization
  - Can be used to:
    - obtain different molecular shapes e.g. branched, crosslinked
    - obtain defined chain-end termination e.g. OH or COOH
    - tailor the hydrolytic degradability of the polymer
    - modify the processing properties or mechanical properties of the polymer
- Chain extension of telechelic prepolymers → results in higher molar masses
- Post polymerization modification
  - Peroxide-initiated crosslinking
  - Radiation-induced crosslinking e.g. Electron beam (EB)
- Stereocomplex formation
  - Different crystal form resulting in better hydrolytic and thermal stability

3. Tailor-made biopolymers



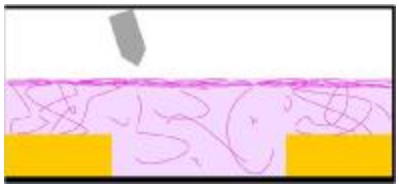
Structure-property tailoring

Biopolymer

Hot melt adhesives (customer trials)

S. Inkinen´s doctoral thesis 2011

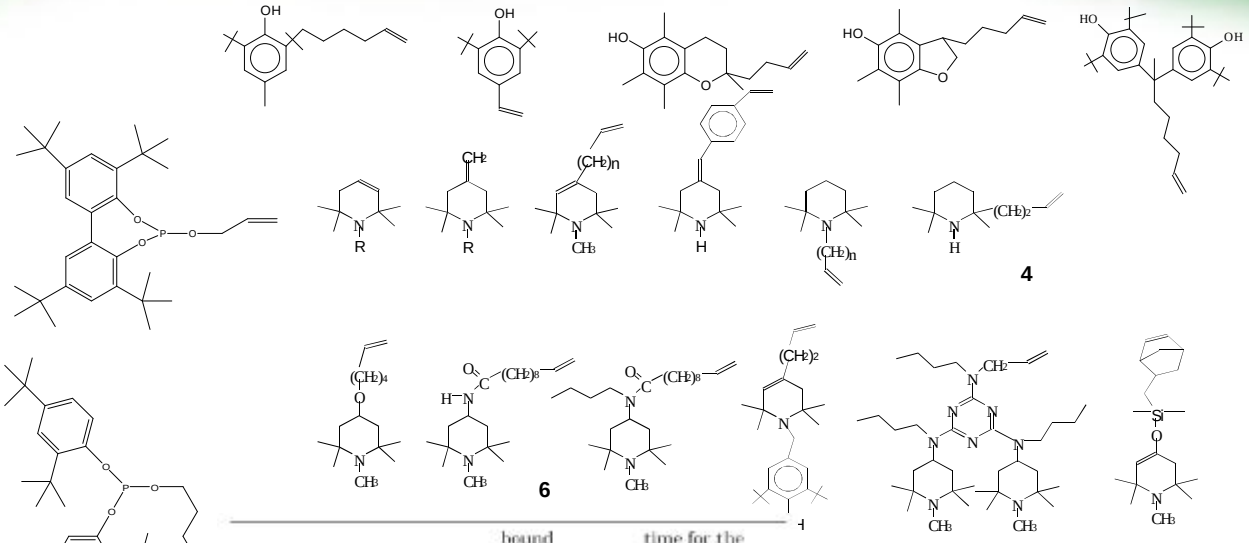
1. S. Inkinen, M. Hakkarainen, A-C. Albertsson, A. Södergård Biomacromolecules 2012
2. S. Inkinen, G. A. Nobes, A. Södergård J.App.Polym. Sci. 2011 119, 2602-1201
3. S. Inkinen, M. Stolt, A. Södergård Biomacromolecules, 2010,11, 1196-1201
4. S. Inkinen, M. Stolt, A. Södergård, Polymers for Advanced Technologies
5. S. R. Andersson, M. Hakkarainen, S. Inkinen, A. Södergård A-C. Albertsson Biomacromolecules 2010, 11(4) 1067-1073.



PLA/P3HT (conductive at 1 wt%) !

Food packaging

4. Plastic additives - chemically bound stabilizers

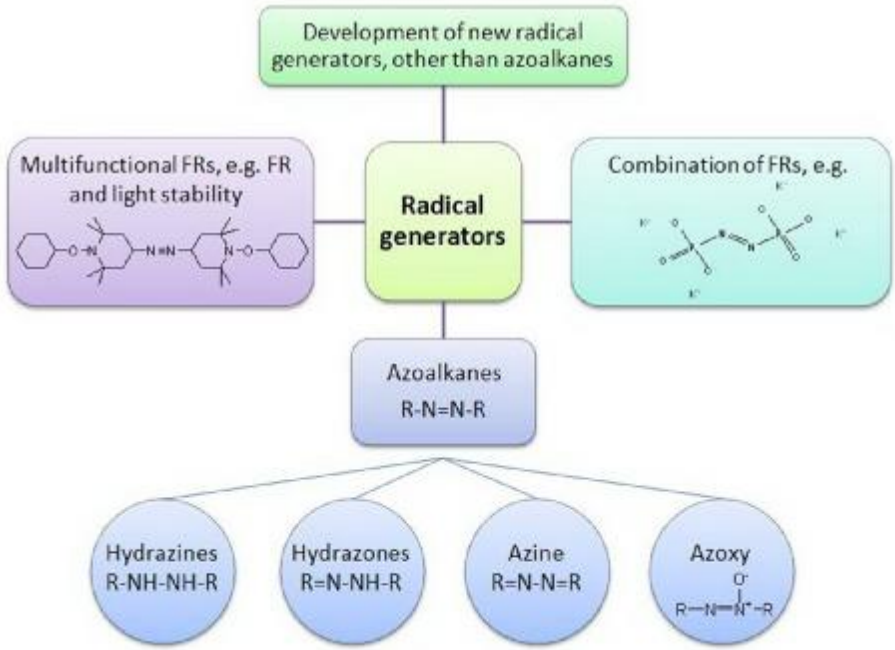


4 **6**

polymer sample	bound nitrogen, wt %	time for the formation of the carbonyl peak, h
Thermo-Oxidative Stabilities after Oven Aging at 115 °C		
polyethylene[a]		48
poly(ethylene-*co*-**4**)[b]	0.2	>8544
Light Stability		
poly(propylene-*co*-**6**)[c]	0.1	2500
poly(propylene-*co*-**6**)[c]	0.2	3900

Accepted book chapter "Antioxidant Polymers Synthesis, Properties, and Applications" to be published by Scrivener Publishing LLC and John Wiley and Sons Ltd. Editors Prof. Iemma and Dr. Cirillo, 2012 (C-E. Wilen "Synthesis of Antioxidant Polymers: Antioxidant Monomers)

4. Development of environmentally friendly halogen free flame retardants



4. Recent flame retardant publications

1. W. Pawelec, M. Aubert, H. Hoppe, R. Pfaendner, C-E. Wilén, "Polymer Degradation and Stability (http://dx.doi.org/10.1016/j.polymdegradstab.2012.03.019)

2. Aubert, M, Wilen, C-E., T. Tirri, R. Pfaendner, Hoppe, H. Roth. M, Polymer Degradation and Stability (in press)

1. T. Tirri, M. Aubert, C-E. Wilén, R. Pfaendner and H. Hoppe, Polymer Degradation and Stability 2012, 97(3), 375-382.

2. Lindholm, J., Brink, A., and Hupa, M., Wilén, C-E. J. of Appl. Polym. Sci. 2012, 3, 1793-1800.

3. Aubert, M, Wilen, C-E., R. Pfaendner, S. Kniesel, Hoppe, H. Roth. M. Polymer Degradation and Stability, (2011), 96(3), 328-333

4. Lindholm, J., Brink, A., and Hupa, M., Fire Mater., 2011. DOI: 10.1002/fam.1087

5. W. Pawelec, M. Aubert, H. Hoppe, R. Pfaendner, C-E. Wilén, Polymer Degradation and Stability (in press).

6. M. Aubert, R. C. Nicolas, W. Pawelec, C-E. Wilén, M. Roth, R. Pfaendner; Polymers *for Advanced Technologies (2011), 2011, 22, 1529–1538.*

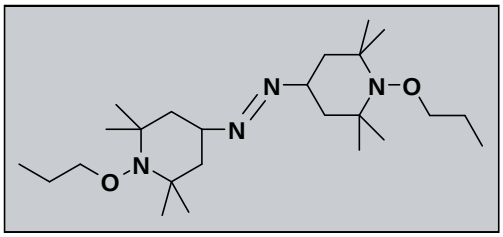
7. *Aubert, M.; Roth, M; Pfaendner, R.; Wilen, C.-E. Macromolecular Materials and Engineering (2007), 292(6), 707-714.*

8. *N, Ronan; Wilen, C-E; Roth, M; Pfaendner, R, King, R. E., III. Macromolecular Rapid Communications (2006), 27(12), 976-981.*

Book Chapter

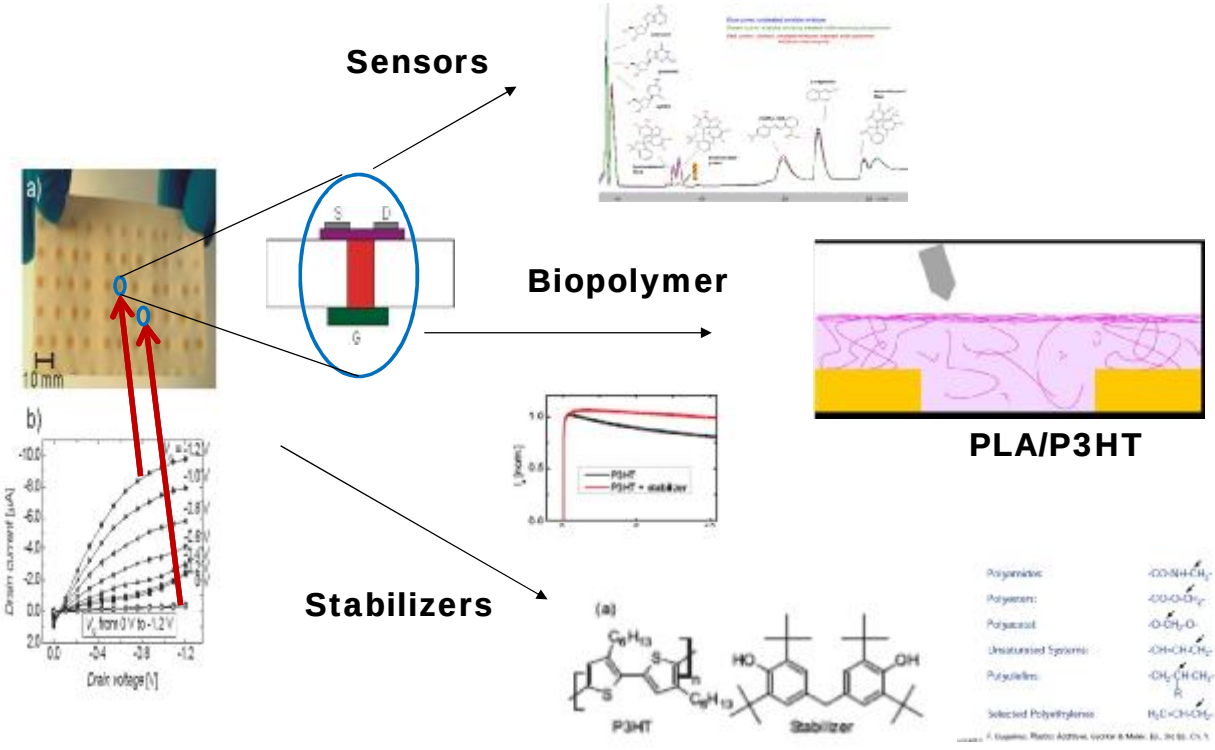
1. C-E. Wilen, R. Pfaendner, Nitrogen-based flame retardants" A new handbook entitled: Polymer Green Flame Retardants: A Comprehensive Guide to Additives and their Applications. Editor: Prof. Constantine (Costas) D. Papaspyrides and Dr. Pantelis Kiliaris; published by Elsevier Ltd in 2012.

4. What makes AZONOR -technology special?



- Ø Effective at very low concentrations in thin films (DIN 4102 B2) => cost-effective, easily processable
- Ø First radical generator to pass UL94 VTM2 test standard by itself => usable in many applications
- Ø Provides both flame retardancy and light stability (WOM 2000 h) => no need for additional light stabilizer
- Ø Good colour and product form => easy to dose
- Ø Excellent interaction with other flame retardant systems => highest fire safety standard can be reached

5. Plastic electronics – further development of MEMFET concept



6. Recent diverse projects

- Richard Kallberg DI 2012, X-ray contrast agents(Bayer)
- Häggblom Eva: Flame retardant Polymer Coatings (080312) DI 130312 (Walki Group)
- Johan Norrgård: DI 2012, Organiska nanopigment vid bestrykning. (BASF)
- Penttinen Sara: Co-Polymerization of Expandable Polystyrene (271211) (StyroChem)
- Paakki Charlotta: In vitro-studie av bionedbrytbara kompositmaterial för ben- och broskåterbildning (130911) DI 031011 (Rusto/Tekes)
- Pahlevan Mahdi: Synthesis of poly-amide based macrocycles (230511) DI 010711 (Optibind/Tekes)
- Tan Chen: Synthesis of poly-amide based macrocycles (060511) DI 230511 (Bioactive/Tekes)
- Holappa Anton: DI 10711 Evaluation of properties of melt processed thermoplastics (KWH-pipe)

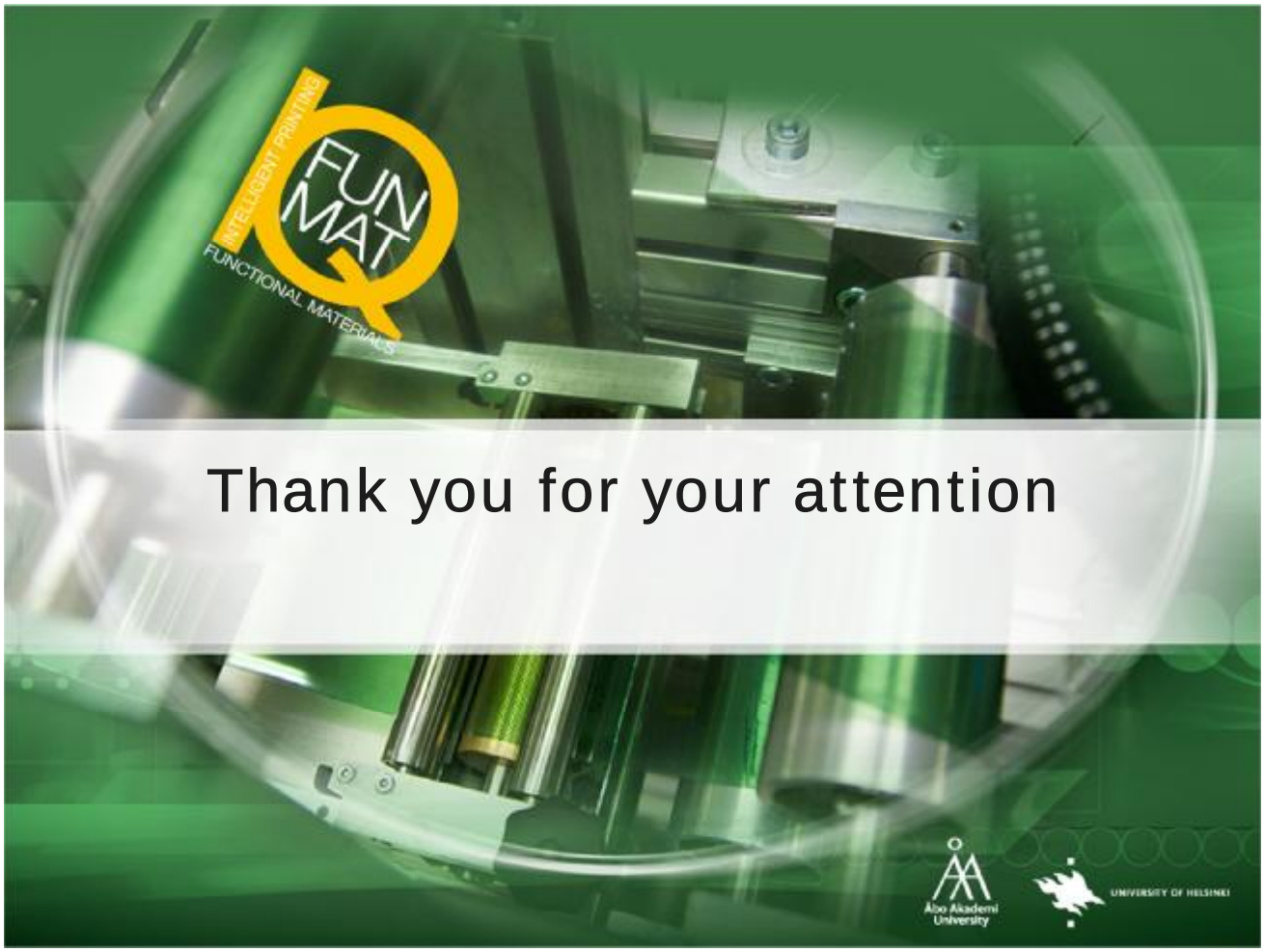
Acknowledgment

- Ordinary Staff
  - Professsor Carl-Eric Wilén
  - Academic Lecturer Ari Rosling
  - Lab. Manager. Carl-Johan Wikman
  - 0.5 Lab. Technican Roger Nordqvist
  - Econ. Sec. Christina Luojola

Research staff, :

1. Mia Ahokas
2. Ove Andell
3. Melanie Aubert
4. Mia Borg
5. Jie Duanmu
6. Anton Holappa
7. Saara Inkinen
8. Richard Kalberg
9. Rickard Linde
10. Mohammad Khajeheian
11. Rafieh Norouzian
12. Robert Nilsson
13. Mahdi Pahlevan
14. Weronika Pawelec
15. Charlotta Paakki
16. Sara Penttinen
17. Magnus Perander
18. Tommi Remonen
19. Pernilla Sund
20. Chen Tan
21. Mikael Thylin
22. Teija Tirri
23. Peter Uppstu
24. He Xuehan
25. Yanxi Zhang

Thank you to all FUNMAT members and collaboration partners!


INTELLIGENT PRINTING
FUNCTIONAL MATERIALS
FUN MAT
Thank you for your attention
Åbo Akademi University
UNIVERSITY OF HELSINKI