BioSPRINT Webinar #3

Industrial perspectives on biomass feedstocks and bio-based products

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7 June 2022, 3:00 pm CET

AEP POLYMERS

- Funded in 2013
- **independent SME** based in Area Science Park (Trieste) and focused on **industrial R&D**
- development of new **bio-based** building blocks and formulations
- main application in composites, polyurethanes, coatings and adhesives

- Sound expertise and reputation in the **valorization** of bio-renewable sources:
  - CNSL (Cashew Nutshell Liquid)
  - lignin and lignin derivatives
  - plant derived oils

- AEP is **member** of:
  - BIC (Biobased Industries Consortium)
  - Italbiotec Consortium

EXPERTISE & EQUIPMENT

- **Organic chemistry** on fossil-based and bio-based derivatives
- Design, optimization and upscaling of **synthetic processes** for monomers and polymers
- Performance assessment and benchmarking of new (bio-based) materials in **industrial case studies** to support **decision making**
- **Polymer science**: design of formulations with attention to process parameters, performances, cost and sustainability
- **Application development**: definition of technical requirements and new application sectors

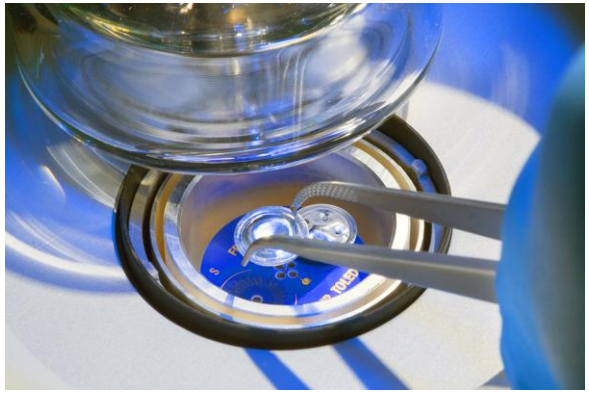
- **Chemical reactors** (design and synthesis of new molecules, scale-up and optimization up to 5L volume)
- **Pressure reactor** (0.75L, 100 bar)
- **Ozone generator** (ozonolysis reactions)
- **HPLC-GPC** (chemical characterization)
- **FT-IR** spectrophotometer
- **Automatic titrator** + Karl Fisher (IPC and QC analyses)
- **Viscometer** (viscosity, polymer/formulation stability)
- **DSC** (glass transition temperature, enthalpy of reaction, fusion)
- **Universal Testing Machine** (tensile, flexural, compression, adhesion tests)
- **Ovens** (controlled curing of thermosetting polymers, thermal ageing of specimens)
- **Compounder** for thermoplastic polymers

MAIN EQUIPMENT

5L jacketed glass reactor for upscaling of chemical syntheses

Jacketed steel pressurized reactor (100 bar)

HLPC-GPC



Differential Scanning Calorimeter (DSC)

Universal Testing Machine

Compounder for thermoplastic polymers

INDUSTRIAL APPLICATIONS

Main application sectors are:

- Polyurethane rigid foams (e.g. thermal insulation for energy efficient buildings)
- Polyurethane flexible foams
- Fiber-reinforced composite (automotive, constructions)
- CASE (Coatings, Adhesives, Sealants & Elastomers)
- Thermoplastics

PU spray foam application

Flexible PU foam for car seat

Carbon-fibre composite frame of BMW i3

(All pictures from Google Images)

THREE ROUTES TO WORK WITH INDUSTRY

Consulting

- Short/medium term commitment
- Narrower definition of work

Master Service Agreement

- Broad developmental work
- Longer term commitment
- Adaptive work plan
- Priority dedicated R&D time
- Not only R&D, but also: assistance on regulations (EU-REACh, TSCA, etc.), preparation of TDS, technical support to sales force

Collaborative R&D funded projects

- Mainly EU programs under Horizon 2020 / Horizon Europe
- 3-20 partners (depending upon the funding scheme, ambition and complexity of the project)
- Useful to explore new raw materials (e.g. lignins) and new collaborations with industries and RTO's

A FEW EXAMPLES

1. Long-term MSA
2. Testbed services
3. BioSPRINT project

1. LONG-TERM MSA

Development of product catalogues

1. Design and optimization of synthetic protocols
2. Characterization, testing and usability assessment
3. Assistance on regulations (EU-REACh, TSCA, etc.)
4. Preparation of TDS
5. Technical support to sales force

Product	Color[1] (Gardner)	Avg. OH value[2] (mg KOH/g)	Viscosity[3] 25°C (cPs)	Avg. OH Func.[4]	Bio-content[5] (%)	Description	Foam Applications
LITE 9001	6	175	2,000	4.3	88	- Light color version of NX-9001 - Very fast cure - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-9001	18	175	2,000	4.3	88	- Excellent alkaline resistance - Low water absorption - Good mechanical properties and fire resistance - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-9001LV	18	175	1,000	3.8	91	- Low viscosity version of NX-9001 - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-9004	18+	198	5,000	4.1	93	- REACH compliant version of NX-5285 - Higher viscosity - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-5285	18+	200	2,500	3.5	93	- Fast cure - Cost effective - Low water absorption - Good mechanical properties and fire resistance - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
LITE 9006	14	175	2,250	3.3	95	- Light color version of NX-9006 - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-9006	18	190	3,000	4.4	95	- Slower cure - Cost effective - Low water absorption - Good mechanical properties and fire resistance - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-9007	14	175	2,900	3.3	80	- Higher strength and elongation - Good water resistance	- Spray foam - Continuous PUR panels - Rigid boardstocks - High-med index PIR
NX-9008	10	340	3,000	3.0	61	- High strength polyether polyol - Good stability in HFO blown formulas	- Spray foam - Continuous PUR panels - Rigid boardstocks

FormuLITE Properties Selection Chart

New!

Part A Part B	FormuLITE 2500A FormuLITE 2401B	FormuLITE 2501A FormuLITE 2401B	FormuLITE 2502A FormuLITE 2401B	FormuLITE 2501A FormuLITE 2002B	FormuLITE 2501A FormuLITE 2405B	FormuLITE 2501A FormuLITE 2009HSFB
Key Advantages	Good mechanical properties	High Tg and mechanical properties	Low viscosity with long pot life	High bio-content with fast cure	Room temperature cure and mould release	Light color, high Tg and mechanical properties
Mix ratio by wt	100:30	100:31	100:33	100:52	100:41	100:29
Initial Mix Viscosity at 25°C (cPs)	700	905	480	1100	1635	1680
Pot life at 25°C (min)	105	95	125	58	28	54

2. TESTBED SERVICES

What we do

- **Usability study** of bio-based materials / new molecules as functional additives / ingredients in industrial formulation
- Design and organic syntheses of **new molecules**
- **Testing** against commercial benchmarks

Target polymers and industrial applications

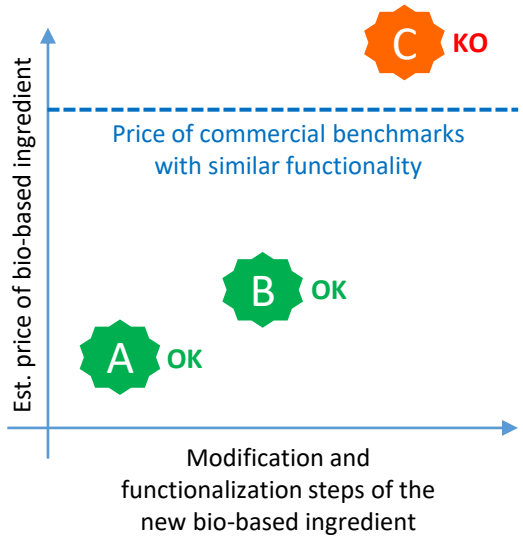
- Polyurethane **foams** (rigid and flexible)
- Polyurethane **adhesives** and **CASE**
- **Epoxy** systems (composites, adhesives, coatings)
- **Thermoplastics** new

Scale

- TRL=**3-5**
- Chemical syntheses: from few grams to 3-5 kgs
- Formulation work: from 50g to 3-5 kgs

Amounts are **enough** to:

  - Fully characterize the new material or formulation for the given application
  - Prepare a draft Technical Data Sheet
  - Send samples for testing to customer or its partners
  - Take decisions based on Costs vs. Performance & Usability



2. TESTBED SERVICES

Technical feedbacks

Benchmarking against commercial references

Customer

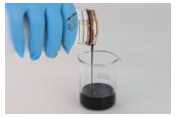
Starting materials

Processing and chemical functionalization

Formulation and testing

Lignin

Proteins, fillers from MSW, etc.



Bio-based oils

Bio-based molecues

Processing, improvement of dispersion

Chemical synthesis

Testing of target performance in industrial formulations

- Flame retardancy
- Reactivity
- Chemical resistance
- Mechanical properites
- Etc.

2. TESTBED SERVICES: Usability of Lignin

Customers

- Large Enterprises
- SMEs

from allover Europe

Typical work flow

- **Characterization** of the starting lignin
- Identification of the most promising **industrial applications**
- Identification of the **key performance properties**
- **Formulation** trials and troubleshooting
- **Testing** of the lignin-based materials
- Maximization of the **lignin-content**

Outcomes

- **Usability** of the lignin grade in specific applications, based on experimental evidences and comparision against benchmarks
- **Suggestions** on how to improve it for use in polymers (e.g. further purification, modification of pH, customized processing)
- Suggestion of **alternative uses** / formulations

Specimens of reference and lignin-based rigid polyurethane foams

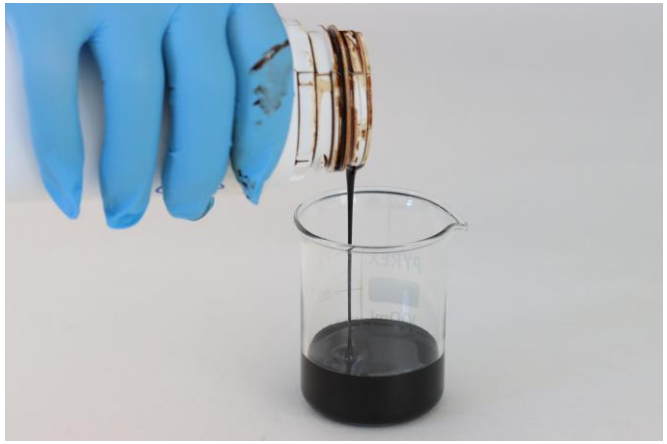
Reference (left) and lignin-based (right) specimens of 2K polyurethane adhesives

Agile planning & execution

The work plan can be changed *in itinere*

3. R&D PROJECTS - BioSPRINT

- WP4 leader
- Synthesis of novel bio-based polyols:
  - From furfural and 5-HMF
  - REACH compliant
  - Usable in rigid polyurethane foams
- Formulation and benchmarking against commercial polyols



Example of a furfural-based Mannich polyol

Specimens of rigid polyurethane foams containing increasing amounts of furfural-derived polyols

OUR APPROACH IN DEVELOPING NEW POLYMERS

- **Performance** is key
- Production **costs** must be in line with existing fossil-based products
- Bio-based raw materials have to be selected with a **multi-criteria approach**
- Unless the new products are based on totally new technologies, the production process should be easy to be upscaled (**industry-friendly**), using existing operations or equipment Mild process conditions and low toxicity solvents have to be preferred
- The **bio-based content** can be maximized by combining different bio-based sources
- **Overall environmental impact** of a new bio-based product should be measured

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