

BioSPRINT

Biorefining of sugars via Process Intensification

Research and Innovation action (RIA) – Horizon 2020-BBI-2019-SO2-R6

Improve biorefinery operations through process intensification and new end products

D7.8 BioSPRINT TECBP workshops



This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 887226. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

Document Information

Grant Agreement No	887226	Acronym	BioSPRINT
Full Title	Biorefining of sugars via Process Intensification		
Start Date	M1, June 1 st , 2020	Duration	48 months
Project URL	http://www.biosprint-project.eu/		
Deliverable	D7.8 BioSPRINT TECBP workshops		
Work Package	WP 7 - Dissemination and Exploitation		
Contractual due date	M38, July 31 st , 2023	Actual submission date	July 29 th , 2023
Nature	Websites, Patents Filing	Dissemination Level	PU
Lead Beneficiary	NIC		
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Contributions from	NIC		

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Refer to this deliverable as: "BioSPRINT – D7.8 (2023), Deliverable D7.8 - BioSPRINT TECBP workshops".

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Glossary of terms and abbreviations used

Abbreviation / Terms	Description
TECBP	Training, Education & Capacity Building Programme
WP	Work Package
PI	Process Intensification
BBI JU	Bio-based Industries Joint Undertaking
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
AEP	AEP Polymers SRL
DEC	Dechema Gesellschaft Fuer Chemische Technik Und Biotechnologie E.V.
NIC	National Institute of Chemistry
UNEW	University Of Newcastle Upon Tyne
UOULU	Oulun Yliopisto (University of Oulu)

1 Executive Summary

The BioSPRINT project is dedicated to implementing process intensification (PI) techniques in biorefining operations. Its primary objective is to enhance the efficiency of purifying and converting the hemicellulose fraction of lignocellulosic biomass, enabling the production of bio-based resins as substitutes for fossil-based polymers in various applications. The project follows an integrated biorefinery concept, emphasizing "zero-waste" bio-based operations. BioSPRINT focuses on four key areas: upstream purification, catalytic conversion, downstream purification, and polymerization.

As part of the Training, Education & Capacity Building Programme (TECBP), the BioSPRINT project aims to enhance the participants' skills and promote the philosophy, knowledge, and results of the project. The TECBP comprises several activities, including four online modules, four training and capacity-building workshops, and the BioSPRINT Summer School. These initiatives were organized to cater to a diverse audience, including academia, research institutions, and the industrial sector.

The four training and capacity-building workshops were designed to provide in-depth insights into the different aspects of process intensification in biorefining operations, aligning with the four focus areas of the BioSPRINT project. The organized workshops aimed to engage participants in interactive sessions and facilitate knowledge exchange among experts, researchers, and industry professionals.

Through these workshops, the BioSPRINT project was able to disseminate its findings and advancements to a broader audience, fostering collaboration and expanding the application of process intensification strategies in biorefinery operations. The workshops served as platforms for networking, collaboration, and identifying potential research and development opportunities.

Deliverable Keywords: Education, dissemination, workshops, stakeholder

2 Introduction

Deliverable D7.8 TECBP Plan and Strategy reports on the activities undertaken as part of D7.6 TECBP Plan and Strategy or more specifically in Task 7.2 Training, Education & Capacity Building Program (TECBP), Figure 1. This includes the organizing and implementation of four training and capacity building workshops in four different countries: Finland, Italy, Slovenia, and the United Kingdom. These workshops were conducted in the third year of the project (2023). Each of these workshops was centred around one of the four main themes of BioSPRINT, upstream purification, catalytic conversion, downstream purification, and polymerization. The overall aim of these workshops was dissemination and sharing of knowledge acquired during the project which relate to the field of biorefinery through process intensification strategies.

The workshops were organized by four different project partners (UOULU, UNEW, NIC, AEP) and consisted of several sessions covering different aspects of process intensification related to hemicellulose valorisation. Experts and industry partners shared their insights, research results, and innovative approaches related to the field. As intended, the discussions and interactions during the workshops provided valuable opportunities for networking, collaboration, and identification of potential areas for further research and development.

Furthermore, the workshops aimed to bridge the gap between academia and industry, facilitate knowledge transfer, and provided a platform for researchers, students and industry professionals to exchange ideas, discuss challenges and explore opportunities for collaboration.

The outcomes of the delivered workshops directly contributed to the BioSPRINT project objectives by advancing the understanding of process intensification strategies and their application in biorefinery operations. The knowledge gained and shared during the workshop can serve as a foundation for future research, innovation, and collaboration.

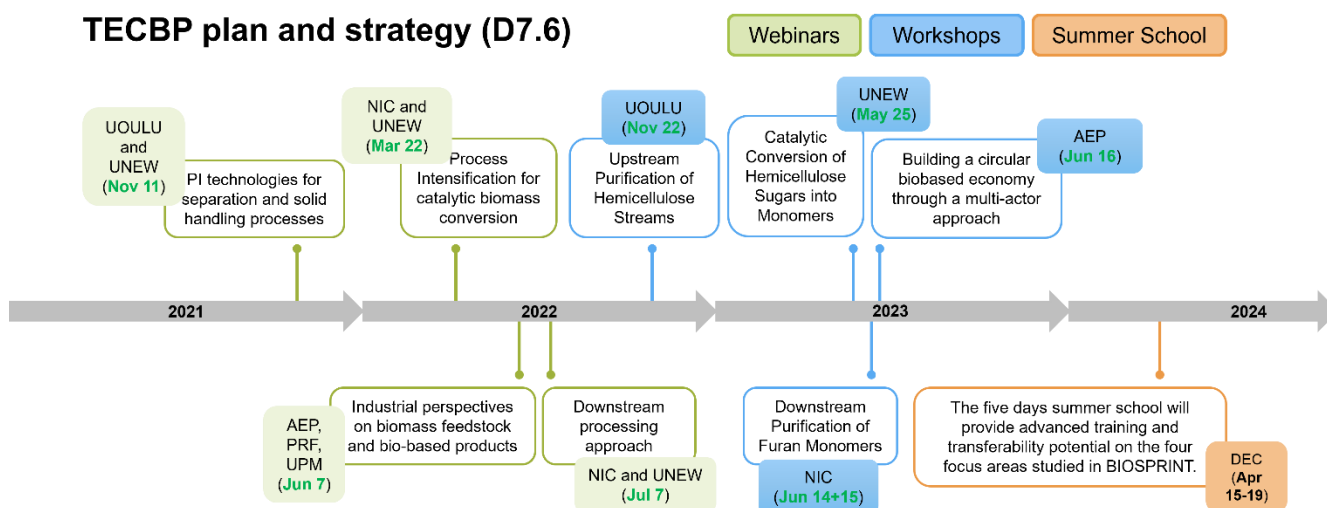


Figure 1: TECBP plan and strategy timeline.

2.1 Mapping Projects' Outputs

The purpose of this section is to map BioSPRINT's Grand Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 1: Adherence to BioSPRINT's GA Deliverable & Tasks Descriptions

BioSPRINT Task		Respective Document Chapter(s)	Justification
Task 7.2 Training, Education & Capacity Building programme (TECBP)	The Task 7.2 includes 4 subtasks with activities including delivery of 4 online modules, 4 training & capacity-building workshops as well as the BioSPRINT Summer School. When delivering the TECBP, attention will be paid to select a broad gender-balanced audience among academia, industry.	Sections 3.1-3.4	Contents and timetables of the workshops within the TECBP activities
BioSPRINT Deliverable			
D7.8 BioSPRINT TECBP workshops			
The deliverable consists of a suite of 4 in-person workshops context-based learning modules.			

2.2 Goal of the Workshops within the Training, Education & Capacity Building programme (TECBP)

The goal of the delivered workshops was to disseminate knowledge gained during various work packages during the BioSPRINT project in addition to promote collaboration in the field of biorefinery process intensification. Furthermore, the workshops focused on improving the understanding and practical application of process intensification strategies focusing on four different areas of the BioSPRINT project: upstream purification, catalytic conversion, downstream purification, and polymerization. By bringing together experts, researchers, and industry professionals, the workshops facilitated the exchange of ideas and identify potential areas for future research and development related to biorefineries and biomass valorisation.

3 TECBP Plan – Overall structure

3.1 Time Schedule and adherence

The Table 2 below, presents the time schedule, responsible partners, targeted groups of audience, date, place and number of registration and participants.

Table 2: Time schedule and adherence of organized workshops.

Workshop title	Responsible partner	Target group	Date	Place	Number of participants	Number of registrations
Upstream purification and concentration of hemicellulosic streams	University of Oulu	Academic research and industrial audiences	16 November 2022	University of Oulu, Finland	22	29
Catalysis and Process Intensification for Sugars Biorefining	University of Newcastle	Academic research and industrial audiences	25 May 2023	University of Newcastle, England	27	30
The Next Challenges of Biorefineries	National Institute of Chemistry	Academic research and industrial audiences	14-15 June 2023	National Institute of Chemistry, Slovenia	72	75
Building a circular bio-based economy through a multi-actor approach	AEP Polymers	Academic research and industrial audiences	16 June 2023	Area Science Park, Trieste, Italy	28	36

3.2 Content of the organized workshops

3.2.1 Workshop No.1

One of the four topics that the BioSPRINT project is focused on within the key PI strategies is upstream purification. Therefore, the initial workshop, held at UOULU in Finland on 16 November 2022 and titled “*Upstream Purification of Hemicelluloses Streams*”, was primarily centred around specific technologies related to upstream purification methods and approaches towards the field of biomass conversion and valorisation. Relevant analytical techniques that were utilized during the upstream purification of the hemicellulose streams which were necessary for saccharide determination and quantification were also discussed.

An overall description of the topics and presenters is shown below in Table 3. Particularly, the workshop included four sessions of keynote lectures where leading members presented their work, followed by an extensive round table discussion where all participants were given the chance to discuss and share their ideas.

At round table 1 (Table host: Kamelia Boodhoo) PI technologies and their challenges in biorefinery environment were discussed, trying to answer following questions:

1. What are your experiences of the most pressing challenges in upstream purification of biorefinery processes?
2. How are these being addressed and how can PI contribute to enhancing these existing solutions?
3. What do you perceive to be the barriers to implementing PI in biorefineries?

Discussion at round table 2 was focused on Process design and simulation (Table host: Juan Enriquez), where participants actively shared their experience and discussed about the topic with a help of following questions:

1. What are your experiences in process simulation? Which software are you experienced with? Which benefits do you see?
2. In what stage of the process design, the control design needs to enter?
3. How to deal with the uncertainty of models?
4. How to select the right level of details in modelling of PI processes?
5. How to manage with different simulation software?
6. What is the connection from CFD to Process Simulation Tools in the plant-wide perspective?
7. What is the precision of the CFD tools and how do you proceed with the validation/calibration process?

Round table 3 (Table host: Ana Jakob) was trying to find solutions for the challenges related with the heterogeneous biorefinery streams and tried to answer a couple questions such as:

1. Where do you see challenges and why?
2. What kind of solutions would you recommend?

The topic of round table 4 was primarily focused on PI potential in solvent and water recovery, trying to share their experience with the PI technologies and define the uprising challenges in the field of solvent water recovery.

As mentioned above, round table 1, moderated by Kamelia Boodhoo, focused on PI technologies and their challenges in the biorefinery environment. Participants shared their experiences and talked about pressing challenges in upstream purification of biorefinery processes. The discussion focused mainly on possibilities of upscaling and industrialization of PI. Round table 2, chaired by Juan Enriquez, focused on process design and simulation. Participants shared their experiences with process simulation software and discussed the benefits they observed. Round table 3, chaired by Ana Jakob, sought solutions to the challenges associated with heterogeneous biorefinery streams. In particular, participants discussed the challenges posed by feedstock variability and its impact on end-product distribution. Finally, round table 4 addressed the potential of PI in solvent and water recovery. Following the discussions, each table chair introduced the discussion topics and shared their views on the specific challenges. The in-depth round table discussions provided valuable insights and ideas for addressing these issues.

Table 3: Description and structure of workshop No.1

Workshop title	Responsible partner	Target group	Place and Date	Number of participants
Upstream Purification of Hemicelluloses Streams	UOULU	Academic research and industrial audiences	University of Oulu, Finland, 16 November 2022	22
Workshop programme: 8:45-9:15 Registration 9:15-9:20 Welcome & Opening: Riita Keiski, UOULU				

9:20-9:50

Key note #1: Intensification of sugar purification and concentration: Show cases with in the BioSPRINT project

- Kamelia Boodhoo, UNEW: Introduction to Process Intensification and its potential for upstream purification in BioSPRINT
- Hanna Valkama, UOULU: Membrane technologies in hemicellulose purification and water recovery

9:50-10:20

Key note #2: Show cases outside the BioSPRINT

- Juha Ahola, UOULU: Impurities in processing of biomass derived saccharides
- Annu Rusanen, UOULU: Utilization of ultrasound pre-treatment in biomass fractionation and recyclable catalysts in the production of platform chemicals
- Vile Tuppurainen, UOULU: Computational solvent screening in early-stage conceptual process design activities: Furfural upgrading case study in the HemiProMo project

10:20-10:50

Break

10:30-10:55

Key note #3: Role of modelling and simulation in process design

- Juan Enriquez, ADSC: Computational fluid dynamics analysis and scale-up suggestions of the main intensification processes developed in BioSPRINT
- Markku Ohenoja, UOULU: Dynamic modelling for the integrated process and control design
- Mladen Crnomarkovic, MAT: Plant-wide modelling and analysis of the integrated biorefinery

10:55-11:15

Key note #4: Stream properties and their analysis

- Ana Maria Lopez, IRIS: Inline analytics of HMC streams
- Ana Jakob, NIC: Challenges related to hemicellulose analyses

11:15-12:30

Lunch

12:30-13:30

Round table discussion

- Table 1: PI technologies and their challenges in biorefinery environment
- Table 2: Process design and simulation
- Table 3: Challenges with the heterogeneous biorefinery streams
- Table 4: PI potential in solvent and water recovery

13:30-14:00

Wrap-up

<https://biosprint-project.eu/workshop-1-upstream-purification-adn-concentration/>



Figure 2: Photos from the first workshop in Oulu, Finland.

3.2.2 Workshop No.2

The second BioSPRINT workshop was organized by Newcastle University on 25 May 2023 and titled: "*Catalysis and Process Intensification for Sugars Biorefining*". Researchers and experts from the field of biomass and process intensification were invited to share their knowledge, including partners of the project consortium.

An overview of the workshop programme is shown below in Table 4. Dr Aki Sorsa, from the University of Oulu delivered a comprehensive online overview on the subject of Data processing and Machine learning. Ana Jakob from National Institute of Chemistry also gave a detailed lecture on the topic of kinetics of sugar conversion. The workshop programme continued with lectures given by Prof. Adam Harvey and Dr Fernando Abegão from UNEW focusing mainly on process intensification technologies. Prof. Avtar Matharu from the University of York shared a presentation on the topic of citrus waste processing by using microwave technology, offering an innovative solution to tackle environmental challenges. Lastly, the event ended with some flash talks and a productive discussion involving all participants.

Table 4: Description and structure of workshop No.2

Workshop title	Responsible partner	Target group	Place and Date	Number of participants
Catalysis and Process Intensification for Sugars Biorefining	UNEW	Academic research and industrial audiences	Newcastle University, 25 May 2023	27
Workshop programme: 9:30-10:00 Arrival and registration 10:00-10:10 Workshop opening and Welcome message Prof Kamelia Boodhoo, Newcastle University 10:10-11:00 Dr Markku Ohenoja, University of Oulu; Machine Learning for Catalyst Development				

11:00-11:40

Coffee break, networking and poster session

11:40-12:30

Ana Jakob, National Institute of Chemistry, Slovenia; Sugar conversion kinetics

12:30-13:30

Lunch, networking and poster session

13:30-14:15

Prof Adam Harvey, Newcastle University; Overview of Process Intensification and Research at Newcastle

14:15-15:00

Dr Fernando Russo Abegão, Newcastle University; Process Intensification in BioSPRINT

15:00-15:30

Coffee break, networking and poster session

15:30-16:00

Prof Avtar Matharu, Green Chemistry Centre of Excellence, University of York; Citrus waste processing using microwave technology

16:00-16:20

Flash talks

16:20

Closing remarks

<https://biosprint-project.eu/workshop-2-catalysis-and-process-intensification-for-sugars-biorefining/>



Figure 3: Photos from the second workshop in Newcastle.

3.2.3 Workshop No.3

The third workshop was organized by the consortium partner NIC as a two-day event on 14-15 June 2023 in collaboration with the "Bilateral Project Portugal – Slovenia". Not only did this attract a large attendance of over

70 participants, this also allowed additional opportunities to share knowledge and to initiate possible collaborations with an even wider and more diverse range of researchers and professionals in the field of biomass conversion and valorisation. The agenda of the workshop entitled “*The Next Challenges of Biorefineries*” covered a variety of relevant topics including the recovery of valuable products, solvents, and sugar residues with an emphasis on valorisation of valuable products from diverse biomass sources. Moreover, the benefits and challenges associated with the utilization of ionic liquids and deep eutectic solvents (DES) in the biorefining process were thoroughly discussed by experts in this given field.

The outline of the two-day workshop is presented below in Table 5. It included Prof. Dr Blaž Likozar, head of the Department of Catalysis and Chemical Reaction Engineering at NIC, with an overview of his group’s work. Subsequently, two presentations were delivered, elucidating the valorisation of lignocellulose and the operation of ethanol-based biorefineries, respectively. Fernando Russo Abegão from UNEW and Ljudmila Fele Žilnik from NIC presented the BioSPRINT approach as an illustration of process intensification strategies in catalytic conversion and downstream biorefining processes. Nataša Čuk from Helios joined the workshop as an industrial partner from the polymer industry and shared their experience with bio-based polymers, more precisely the valorisation of FDCA in resins for coil coatings. The keynote lecture presented by Robin Rogers from the esteemed University of Alabama addressed an important question in the biomass community: "What are the indispensable elements for achieving success in a biorefinery process?" The session concluded with a discussion led by Erick Pastor, another industrial partner, exploring the topic of transitioning from research and development to the market.

The second day of the workshop started with a keynote presentation delivered by João A. P. Coutinho, from the University of Aveiro in Portugal. This talk was followed by a series of presentations that provided the latest insights into the applications of ionic liquids and deep eutectic solvents (DES). Roland Kalb from Proionic GmbH, invited as an industrial partner shared their knowledge and experience about delignification of Lignocellulosic Biomass Utilizing Distillable Ionic. The BioSPRINT consortium's third presentation was delivered by Andrea Minigher from AEP Polymers about the development of novel bio-based polymers for industrial applications.

Table 5: Description and structure of workshop No.3

Workshop title	Responsible partner	Target group	Place and Date	Number of participants
The Next Challenges of Biorefineries	NIC	Academic research and industrial audiences	National Institute of Chemistry – Slovenia, 14-15 June, 2023	72
Workshop program: Day 1		Day 2		
8:40 Registration 8:55 Opening Session 9:00 Blaž Likozar (National Institute of Chemistry Slovenia); Catalytic Processes for Engineering Bio-derived Monomer Materials 9:25 Mija Sežun (Institute for Cellulose and Paper); From underutilized lignocellulosic biomass to high added value products 9:50 Edita Jasiukaityte Grojzdek (National Institute of Chemistry Slovenia); Ethanol-based biorefinery:		8:55 Morning Session 9:00 João A. P. Coutinho (CICECO, Chemistry Department, University of Aveiro, Portugal); Water based solutions for biorefineries 10:00 Roland Kalb (proionic GmbH); HIPE-REC® - Delignification of Lignocellulosic Biomass Utilizing Distillable Ionic Liquids in an Advanced Process Environment 10:25 Giorgio Tofani (National Institute of Chemistry Slovenia); Modification of Kraft lignin for its application as recyclable biobased epoxy resin with covalent adaptable network		

<p>corellation between lignin characteristics and operating parameters 10:15 Fernando Russo Abegão (Newcastle University); Process Intensification Strategies in Biorefineries Downstream Processing 10:40 Coffee break 11:05 Ljudmila Fele Žilnik (National Institute of Chemistry Slovenia); Solvent selection and downstream purification in BIOSPRINT 11:30 Nataša Čuk (Helios); FDCA in resins for coil coatings 11:55 Olga Pantic (Institute of Chemistry, University of Belgrade); Biobased unsaturated polyester resins- step towards biorefinery solution 12:20 Mojca Zupanc (Faculty of Mechanical Engineering, University of Ljubljana); Process intensification through cavitation 12:45 Lunch break 14:30 Afternoon Session 15:00 Robin Rogers (The University of Alabama/525 Solutions, Inc., USA); The Next Challenges of Biorefineries: Roadblocks, Detours, and Areas Under Construction 16:00 Filipa A. Vicente (National Institute of Chemistry Slovenia); Unlocking the Potential of Food Waste Valorization: Sustainable Products and Circular Economy Solutions - 16:25 Jorge F. B. Pereira (CIEPQPF, Department of Chemical Engineering, Faculty of Sciences and Technology, University of Coimbra, Portugal); Colorant Microbial Biorefineries: Challenges in Selecting the Optimal Solvent for Cell Disruption and Carotenoids Extraction 16:50 Erick Pastor; From Lab to Market: Navigating the Challenges of Commercializing Novel Scientific Inventions 17:15 Closing session</p>	<p>10:50 Coffee break 11:15 Andrea Minigher (AEP Polymers); Development of novel bio-based polymers for industrial applications 11:40 Uroš Novak (National Institute of Chemistry Slovenia); Keep innovations as a scientific contribution or trying to cross the valley of death? 12:05 Sanja I. Šešlija (Institute of Chemistry, University of Belgrade); Deep eutectic solvents mediated extraction of pectin from apple pomace: Optimization and characterization studies 12:30 Lab tour 13:00 Lunch break 14:30 Afternoon Session 14:30 Sónia P. M. Ventura (CICECO, Chemistry Department, University of Aveiro, Portugal); Application of alternative solvents in the development of more sustainable downstream processes for algae- and marine bacteria-based biorefineries 15:00 Ana Rotter (National Institute of Biology); Launch of new biorefineries using marine biomass 15:30 Annamaria Vujanović (Faculty of Chemistry and Chemical Engineering, University of Maribor, Slovenia); LCA as a tool in designing zero-waste biorefinery 16:00 Coffee break 16:25 Matej Žula (National Institute of Chemistry Slovenia); Understanding hydrodeoxygenation catalysts through kinetic analysis - preparation of renewable fuels 16:50 Claudio Santi (CS-OrGChem -Catalysis Synthesis and Organic Green Chemistry, University of Perugia); Selenium based catalysts for new eco-friendly oxidation and the treatment of biomasses 17:15 Closing Session</p>
<p>https://biosprint-project.eu/workshop_3_workshop_4/</p>	



Figure 4: Photos from the third workshop in Slovenia, at NIC.

3.2.4 Workshop No.4

The fourth and final workshop took place on 16 June 2023 in Trieste and was organized by the consortium partner AEP Polymers. The workshop programme, displayed below in Table 6, covered a wide range of relevant and informative topics related to polymers. Overall, participants were able to gain comprehensive insights into polyurethanes, phenolic resins, and polylactides. Additionally, discussions also focused on current trends and challenges in sustainable polymers, including lab scale testing, life cycle analysis, and the application of modelling and machine learning to link sustainability with the development of new polymers. Prof. Maurizio Fermeglia (University of Trieste) discussed how molecular simulations can inform business decisions: from properties to environmental impact. Francesca Marchi and Francesca Furlan from Area Science Park shared their knowledge about bridging research, sustainability, innovation and business areas. David Contus and Andrea Minigher (AEP Polymers) also introduced and explained the role of the OH-NCO reaction and current approaches in the field of sustainable polyurethanes foams. Dr Anamaria Todea from University of Trieste gave a lecture on sustainable route for circularity of renewable polyesters: the RenEcoPol project, while Elke Fliedner (Prefere Resins) as a BioSPRINT project partner provided an overview on the applications of phenolic resins. Lastly, Vittorio Bortolon from MediaTech led an informative discussion on the latest developments in the industrial use of polylactide. During the networking lunch, participants and speakers had the opportunity to engage in discussions about the workshop content and explore the possibilities of applying bio-based polymers.



Figure 5: Photos from the fourth workshop in Italy, Trieste.

Table 6: Description and structure of workshop No.4

Workshop title	Responsible partner	Target group	Place and Date	Number of participants
Building a circular bio-based economy through a multi-actor approach	AEP Polymers	Academic research and industrial audiences	Area Science Park, Trieste, Italy, 16 June 2023	28
<p>Workshop programme:</p> <p>8:45 Arrival and registration</p> <p>9:00 Workshop opening and Welcome message Andrea Minigher (AEP Polymers)</p> <p>9:05 How molecular simulations can inform business decisions: from properties to environmental impact Prof. Maurizio Fermeglia (MoIBNL - University of Trieste)</p> <p>9:35 Area Science Park: a technology park, a research center or an innovation agency? Initiatives on sustainability Francesca Marchi (Area Science Park)</p> <p>9:50 Market and Technology Scenarios: a strategic tool for business and research Francesca Furlan (Area Science Park)</p> <p>10:05 The OH-NCO reaction: a world to discover David Contus (AEP Polymers)</p> <p>10:40 Coffee break</p> <p>11:00 Current approaches to sustainable polyurethanes Andrea Minigher (AEP Polymers)</p> <p>11:30 Sustainable route for circularity of renewable polyesters: the RenEcoPol project Dr. Anamaria Todea (University of Trieste)</p> <p>12:00 Phenolic resins today Elke Fliedner (Prefere Resins)</p> <p>12:30 Frontiers in the industrial use of polylactic acid Vittorio Bortolon (MediaTech)</p> <p>13:00 Closing remarks</p> <p>13:10 Lunch and networking</p> <p>https://biosprint-project.eu/workshop_3_workshop_4/</p>				

4 Conclusions and Next Actions

All four of the individual workshops which covered and emphasized the four key themes of BioSPRINT, have been successfully completed. The combined workshops attracted a large number of over 140 participants which included a wide range of students, researchers, and industrial partners spanning different research fields relevant for biomass conversion and biorefineries. As planned, this permitted ample opportunities for both experts and new researchers to share knowledge and to initiate possible collaborations. Thus, the overall goal of the delivered workshops to promote collaboration and allow the exchanging of knowledge and ideas between individuals, groups, and even fields of research has been satisfied. This is anticipated to facilitate and enable new prospective research and development opportunities in the future related to biomass conversion and biorefineries. As next part of the TECBP programme, the BioSPRINT Spring School will follow in April 2024 and will be held in Frankfurt, Germany.