H2020-SC5-2018-2: PLASTICS TO BE CLEANED BY SORTING AND SEPARATION OF PLASTICS AND SUBSEQUENT RECYCLING OF POLYMERS, BROMINE FLAME RETARDANTS AND ANTIMONY TRIOXIDE

D6.16 WORKSHOP 2

Project details			
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1. TERMS, DEFINITIONS AND ABBREVIATED TERMS

ABBREVIATION LIST			
Acronym	Definition	Acronym	Definition
ABS	Acrylonitrile butadiene styrene copolymer	ATO	Antimony Trioxide
BFR	Brominated flame retardants	rABS	recycled Acrylonitrile Butadiene Styrene copolymer
EoL	End-of-Life	WEEE	Waste of Electrical and Electronic Equipment
ICT	Information and Communication Technology	LCA	Life Cycle Assessment
LCC	Life Cycle Costing	IERC	Electronic Recycling Congress

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PUBLISHABLE SUMMARY

PLAST2bCLEANED's aim is to develop a recycling process for Waste of Electrical and Electronic Equipment (WEEE) plastics in a technically feasible, environmentally sound, and economically viable manner. To fulfil this aim, PLAST2bCLEANED addresses the recycling of the most common WEEE plastics acrylonitrile butadiene styrene (ABS) and high impact polystyrene (HIPS) that contain up to 20 wt.-% brominated flame retardants (BFR) and up to 5 wt.-% of the synergist antimony trioxide (ATO). PLAST2bCLEANED will close three loops: (1) polymer, (2) bromine, and (3) ATO.

The deliverable D6.16 presents the proceedings and outcomes of the final workshop held at the International Electronic Recycling Congress (IERC) in Salzburg as well as the final webinar at the closure of the project. Both events disseminated the PLAST2bCLEANED project outcomes into more detail. Over the course of three hours, participants engaged in presentations, discussions, and assessments aimed at fostering understanding and dialogue surrounding the innovative technology.

This report aims to provide a comprehensive overview of the key discussions, findings, and recommendations that raised from the workshop, shedding light on the potential implications for industry, sustainability, and technological progress.

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2. OBJECTIVE

The main objective of the PLAST2bCLEANED workshop at the International Electronic Recycling Congress (IERC) in Salzburg and the final webinar (online) was to display the results and accomplishments of the project to the wider audience. The purpose of the workshop at the IERC in Salzburg was to show the results to the industrial stakeholders of the entire electronics recycling values chain. The target audience were especially professionals dealing with producing or recycling plastics with bromine containing flame retardants that might be interested investing in the further development of the technology.

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3. AGENDAS OF THE WORKSHOP AND WEBINAR

1.1 IERC 2024 WORKSHOP

The workshop was held on Friday, January 24, 2024, and the agenda provided in Table 1 below outlines the session's schedule. The event was planned for a duration of 3 hours, with the bulk of the time dedicated to presenting a PLAST2bCLEANED dissolution process. This was followed by a detailed explanation of cutting-edge pre-sorting methods and an assessment of the technology's environmental and economic viability. In the break, the participants had the opportunity to experience the materials and end-products from this project for themselves and dive into more technical questions with the presenters. In a short presentation, the importance of this technology on a European scale was explained as well as how this technology can solve some current key challenges that the industry is dealing with. At last, a panel discussion was held with all the main stakeholders of the project, discussing its the further implementation.

TABLE 1 AGENDA AT THE IERC 2024

Time	Duration	Topic	Presenter/panel member(s)
9:00-9:15	**15 min**	**Welcome + Intro**	Judith Kessens
9:15-10:30	**75 min**	**P2BC results**	
	45 min	P2BC process	Sebastian Reinhardt/Lucie Prins
	15 min	Advanced sorting	Ainara Pocheville
	15 min	Impact Assessment	Spela Ferjan
10:30-11:00	**45 min**	**Break & "show & tell"**	PLAST2bCLEANED consortium and participants
11:00-11:20	**20 min**	**Impact for Europe**	Tom Caris
11:20-12:00	**40 min**	**Panel discussion implementation**	Tom Caris, Rolands Jaunzems, Marco Garilli

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2.1 FINAL ONLINE WEBINAR

The final webinar on 23.02.2024, started at 9.30 and due to the online presentation a distribution of breaks was different than in the IERC workshop to accommodate the online participation.

TABLE 2 AGENDA AT THE FINAL WEBINAR

Time	Topic	Presenter/panel member(s)
9:30-9:40	**Welcome + Intro**	Judith Kessens
9:40-10:30	**P2BC results**	
9:40 -10:25	P2BC process	Sebastian Reinhardt/Lucie Prins/ Marco Garilli
Short break of 5 minutes		
10:30 – 10:45	Advanced sorting	Ainara Pocheville
10:45 – 11:00	Impact Assessment and Scenario analysis	Spela Ferjan
11:00-11:10	Impact for Europe	Tom Caris
11:10-11:25	**Panel discussion**	Tom Caris, Rolands Jaunzems, Marco Garilli
11:25-11:30	**PLAST2bCLEANED movie**	Mariana Fernandez

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4. PARTICIPANTS

3.1 IERC 2024 WORKSHOP

All together 19t Iparticipants attended the workshop from the following companies:

- The Royal Mint,
- APPLiA,
- BSEF,
- Demcon High Tech Systems BV,
- Kuusakoski Oy,
- Demcon,
- PLASt2BCLEANED consortium members

4.1 FINAL ONLINE WEBINAR

99 people registered for the final webinar, from which 48 people attended. The attendees were from the following companies:

- Elix- polymer
- ICL-group
- Bosch
- HR PSOR
- Campine
- Plastics Europe
- Bomet recycling Inc
- INEOS Group
- IKIGAI Consult SRL
- European Commission
- Orbia
- French Alternative Energies and Atomic Energy Commission (CEA)
- National Technical University Of Athens
- IRIS Technology Solutions
- Trinseo
- Axion Group
- Sabic
- Electrolux
- TNO
- Katholieke Universiteit Leuven
- New Cable Corporation
- Phillips
- IMDEA Energy
- VTT Technical Research Centre of Finland

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5. CONTENT OVERVIEW

The content of the PLAST2bCLEANED presentation was the same at the IERC 2024 workshop and the final webinar.

At the beginning the project manager from TNO introduced the current state of WEEE management in the world and Europe and emphasized the need for improved sorting and recycling of the BFRs from the WEEE waste. She continued with the explanation of the project objectives and its structure and noted the variety of stakeholders from industry to research institutions that form the consortium of this project.

The presentation was taken over by the main scientists that were in the lead of the dissolution technology development, which is the core work of the project. They explained the principles of dissolution and showcased the steps and challenges regarding the removal of ATOs and BFRs. Pictures of the comparison of dissolved polymers with and without additives on a lab scale showed the achievements of the work package. Once the experiments were completed on the lab scale, the process was scaled up to the pilot plant. The presentation documented the chronological progress of the scale-up. The main milestone of the work package was a successful recovery of polymer fraction with minimal solvent residue. The recycled ABS passed all the required quality tests and 23 prototypes of washing machine door frames have been produced from it.

The scientific lead of the development of advanced sorting technology presented the novel technology to improve the mechanical separation processing step that was developed in this project to detect BRFs containing plastic fractions. The presentation detailed the RAMAN spectroscopy methodology used for sensing coloured or dark samples such as BFRs containing polymers. This was coupled with machine learning to train the model for sample classifications. The main outcome of this work package was designing and developing a Raman sorting prototype that can classify the samples with a 60% success rate and 45% purity. Still, further research is needed.

The LCA expert working on evaluating the economic and environmental feasibility of the technology explained the process and results of the Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) that was conducted on the improved sorting of WEEE waste and dissolution pilot plant from waste and product perspective. From waste and product perspective, LCA showed significant CO_2 savings compared to the current practices of treating WEEE waste. On the other hand, the LCC indicated that from waste perspective the PLAST2bCLEANED process can potentially run in an economical manner ranging from substantial financial savings in the base case and to additional costs in case the solvent consumption is massively increased. From the product perspective, it does not have a good business case, since the recycled ABS is more costly than the virgin one. However, CO_2 savings make the process worthwhile from a societal sustainability perspective.

The last presentation focused on the effect of the European policies on the WEEE recycling and the difficulties the recyclers face as a consequence of the

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implementation of these policies. One of the prevalent issues right now is a regulation on the reduction of Bromine content in the plastics fraction to the levels that are difficult to prove with the current state-of-the-art sampling and analysis techniques, making the plastics fractions unrecyclable. The development of dissolution technology holds significant importance in the context of waste management, particularly as the impending export ban on waste streams to Asia and Africa will come to effect. This technology has the potential to change how waste is processed and recycled, particularly in Europe, where there will be a surge in waste volumes due to the ban.

During the break at the IERC 2024, the participants had the opportunity to see the final outcomes of the project such as a successful demonstration of the usage of recycled ABS in the washing machine door frame.

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6. VISUAL MATERIAL

The following set of pictures present the activities taken place at the IERC 2024 workshop and the final webinar.

FIGURE 1: PICTURES TAKEN AT THE IERC 2024 WORKSHOP

FIGURE 2 : PICTURES TAKEN AT THE SET OF THE FINAL WEBINAR

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7. Outcomes and Participant feedback

As the final part of the workshops a panel discussion took place between three panellist who are the project's stakeholders. A constructive/ insightful discussion had developed between the panellists and the audience regarding the challenges and future potential of the PLAST2bCLEANED in both events. The main points of discussion are summarized below.

Challenges for PLAST2bCLEANED technology include further research on separation techniques, as well as improving the efficiency and yields of the dissolution technology. Besides the recovered polymer the antimony and bromine material loops are still not closed and further work is needed to ensure the recovery of the mentioned materials. The biggest technical challenge represents the scale-up process of the technology to the commercial level. It is hard to estimate the obstacles that come into play when processing much larger volumes of real waste containing a variety of contaminants.

The challenges are not just technical but also regulatory. There is a big discrepancy between EU countries in waste management policies. A mentioned example was the differences in costs of incineration with energy recovery between countries, which affects the net cost savings and consequently the business case of the alternative novel technology. There should be strong pressure from the European Commission to harmonise the policies and regulations in all EU countries, only then the introduction of the PLAST2bCLEANED technology on the market can be successful. In addition, the novel regulations on the decreasing trend of bromine content threaten the success of the dissolution technology in the next years. Moreover, the recyclers are struggling to recycle bromine-containing plastics since the bromine content is below the detection level (with state-of-the-art sampling and analysis techniques).

Recommendations stemming from the PLAST2bCLEANED project target different stakeholders. For recycling companies, enhancing sorting methods and working closely with the product producers to improve the design for recycling is crucial. Implementing labels and avoiding the use of certain colorants is desirable. Chemical companies are encouraged to take part in discussions for design for recycling and use additives in a way that does not affect WEEE recycling. Furthermore, accelerate the research on BFRs and ATO separation. Producers are advised to investigate the minimal material quality requirement needed for their product, for easier inclusion of recycled material. Policymakers are urged to implement measures such as minimal required recycled content in the product and establishing a separate market for recycled material to avoid competition with low production costs of virgin materials. Recycled materials should take financial credit for emissions reduction through a European accounting framework. At last, the policymakers need to focus on establishing efficient collection systems to support before mentioned circular initiatives.

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Opportunities arising from PLAST2bCLEANED outcomes include further development for other plastic types and expansion into different waste streams like automotive and aviation plastics. Overall, PLAST2bCLEANED presents a promising avenue for advancing circularity in plastics management, with the potential to transform recycling processes and reduce environmental impact significantly.

Overall, the participant feedback has been incredibly positive in both events. Multiple participants expressed the workshop IERC 2024 conference to be one of the most interesting presentations there.

FIGURE 3: PARTICIPANTS OF THE PLAST2BCLEANED WORKSHOP AT IERC2024

FIGURE 4: CONSORTIUM MEMBERS OF THE PLAST2BCLEANED PRESENT AT THE WEBINAR AND PROJECT AT THE CLOSING EVENT

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8. CONCLUSION

In conclusion, the workshops have proven instrumental in achieving their objectives, successfully disseminating the outcomes of our projects to a diverse audience within the waste management sector. The participation of numerous companies emphasised the significance of our findings and the need to address the challenges hindering the further advancement of our technology. The discussions have shed light on the multilayered obstacles facing the further development of this technology and the recycling sector in general. Hopefully, these workshops laid the groundwork for informed decision-making and collaborative efforts toward closing the material loops.

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