Microplastics Advanced Research and Innovation Initiative (MARII)

SUMMARY OF MARII SUMMIT ON MICROPLASTICS

15 - 17 October 2025
Madrid, Spain

MARII: A Global Platform for Scientific Exchange to Advance Research on Microplastics

Advances in detecting microplastics have significantly increased awareness among the public and regulators worldwide regarding their environmental fate and exposure. Researchers, however, continue to identify ongoing limitations in the data, characterized by a lack of standardized methods, which limit the ability to draw definitive conclusions from existing studies. The primary goal of MARII is to bring together experts studying microplastics, allowing them to share insights with one another, while identifying strategies that aim to fill critical knowledge gaps through the development of consistent, reproducible approaches to assess their exposure and potential impacts on both human health and the environment. This collaborative effort is essential to guide informed decision-making and effective management of potential microplastic risks globally.

The MARII Summit on Microplastics held in Madrid, Spain, represents the flagship activity for 2025. The meeting brought together 65 experts from academia, research institutions, industry and the regulatory community to present scientific advances related to the development of analytical methods, exposure assessment and environmental and human health implications. The Summit also provided an opportunity to share progress aligned with various research projects supported by different organizations, including the American Chemistry Council (ACC), Cefic, Japan Chemical Industry Association (JCIA), Plastics Europe, Association of the European Adhesive and Sealant Industry (FEICA), Tyres Europe (formerly ETRMA), International Life Sciences Institute (ILSI), The Microfibre Consortium, BAM and ECETOC, as well as an update on activities developing at Organisation for Economic Co-operation and Development (OECD) and under the United Nations Environment Programme (UNEP). This report summarizes the content presented and discussions held during the MARII Summit on Microplastics.

Learn more about MARII an initiative of the International Council of Chemical Associations (ICCA), please visit: https://marii.org/ or contact info@marii.org.

The views and opinions expressed by the speakers at the MARII Summit are their own and do not necessarily reflect the position of ICCA.

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Analytical Challenges, Exposure and Emissions

The primary objective of the opening session was to highlight key advances and ongoing challenges in the analysis, exposure, and emissions of nano- and microplastic particles (NMPs). Analysis of NMPs in complex biological matrices is an area of growing interest, particularly as an increasing number of studies report the presence of NMPs in human tissues, including blood, liver, kidney, lungs, and brain. Consequently, the speakers focused on analytical methods applicable to complex matrices and on the potential implications of human exposure to NMPs.

Both Dr. Cassandra Rauert (University of Queensland) and Dr. Federica Nardella (Vrije University) provided a summary of their research aligned with the challenges for assessing the presence of NMPs in complex biological matrices. While preliminary results presented in the scientific literature have raised awareness of the potential health impacts that exposure to NMPs may represent, in the absence of standard analytical methods for these matrices, various researchers have also raised concerns regarding the reliability and relevance of the data that has been generated. The presentations from Dr. Rauert and Dr. Nardella aimed to communicate some of the technical challenges, while also suggesting promising advances regarding how data might be more reliably generated.

Analysis of Plastics with Py-GC-MS – Limitations and Challenges

Dr. Cassandra Rauert

Specifically, Dr. Rauert gave an overview of research being progressed at the University of Queensland with respect to the analysis of NMPs in biological samples. Key challenges identified with the analysis of NMPs include the observation that as the particle size decreases the more challenging and uncertain is the analysis. Small particles in complex matrices represents an even greater challenge in that the matrix itself can introduce background interference which can hide the signal of the plastic particle, thereby increasing the likelihood of a matrix interference. Furthermore, while exposure to NMPs is commonly understood to be ubiquitous, their accumulation in biological tissues is expected to result in relatively low concentrations. Analytical methods, consequently, need to have an appropriate level of sensitivity to accurately quantify their detection.

Pyrolysis-gas chromatography coupled to a mass spectrometer (py-GCMS) is an analytical method that thermally decomposes the plastic particles at elevated temperatures, and which causes the plastic to break down into smaller molecules. The controlled fragmentation of a plastic particle by pyrolysis results in the generation of individual molecular fragments that are separated on a gas chromatographic column, and which are then detected using a mass spectrometer detector. Analysis of NMPs by py-GCMS is destructive, since it decomposes the particle, and thereby does not allow for morphological details of the particles to be determined. The method, however, can be coupled with a size fractionation step, which can thus allow quantification of the mass of different sizes of NMPs.

For NMPs comprised of polyethylene, for instance, fragments of long-chained alkenes (e.g. C10, C12 and C14) are typically used for quantification purposes. These long-chain alkenes, however, are also breakdown products of naturally occurring triglyceride lipids. Consequently, the analysis of complex biological samples containing lipids will require careful consideration for how samples are prepared.

For the analysis of a plastic polymer, such as polyethylene, it is particularly important to examine the ratios between the fragments of C10, C12, C14 and C21. While triglycerides will typically fragment into alkenes of C10, C12 and C14, for instance, further consideration of C21 represents a differentiating variable that can be used to increase the level of confidence in identifying polyethylene. The fragmentation of polyethylene will generate a higher ratio of C21 relative to the other fragment markers. Consequently, careful scrutiny of the ratios between C10, C12, C14 and C21 is thus needed to prevent misidentifying triglycerides as polyethylene. Similar matrix interferences are also known for polyvinyl chloride.

In order to improve the overall analysis and reduce the relative impact of the matrix interference, Dr. Rauert presented research aligned with an improved sequential extraction method. The method involves the extraction of a complex matrix, such as blood, that first uses an enzymatic digestion method, followed

by oxidation of organic material by hydrogen peroxide and then sequential filtering of the digestate to separate NMPs. While the method can significantly reduce the presence of interferences, trace levels of triglycerides were observed to remain in the blood samples. Consequently, Dr. Rauert expressed caution using py-GCMS for the quantification of polyethylene and polyvinyl chloride in blood.
Finally, Dr. Rauert presented some final thoughts regarding the role of interferences in the analysis of NMPs, which include the need to select the appropriate pyrolysis products that include a range of markers to sufficiently check for interferences and to consider different sample preparation methods to remove matrix interferences. For all NMP studies researchers should introduce robust background contamination control measures and consider the biological plausibility of data generated. A key question for researchers to consider is whether the data conform to physiological mechanisms of biological adsorption and distribution processes.

Analytical Methods to Assess Human Exposure: Py-GC-MS Application to Human Biological Samples

Dr. Federica Nardella

The presentation from Dr. Nardella greatly complemented the summary given by Dr. Rauert, whereby Dr. Nardella further emphasized the importance of quality assurance and quality control measures, which have been introduced at Vrije University to reduce and eliminate background contamination concerns related to sample handling and preparation. Application of py-GCMS methods was again demonstrated in the analysis of blood samples, which were prepared by digestion using a proteinase enzymatic approach, with digestate filtered using a 700 nm filter, and particles >700 nm analysed by py-GCMS. Samples were processed using a double-shot py-GCMS approach, with the first shot thermal desorbing target analytes at 100-300 °C, and the second shot represented as a flash pyrolysis at 600 °C. The analysis of plastic polymers is supported through the use of calibration standards, recognizing that differences in fragment ratios may differ between 'pristine' NMPs and environmentally weathered NMPs.

To improve communication in the confidence of the quantification of samples, the use of both procedural and field blanks are strongly encouraged in the derivation of a limit of detection (3 x standard deviation of the average blank) and limit of quantification (3.3 x limit of detection). Data above the limit of quantification would thus represent a high level of confidence that the NMPs detected are unlikely a result of background contamination. Dr. Nardella also emphasized the importance of evaluating sample preparation and analysis methods through the use of recovery experiments. In their method development of blood samples, for instance, researchers at Vrije University spiked blood samples with 100-600 ng of various plastic polymeric particles and observed satisfactory recoveries of between 57-102%.

As in the presentation of Dr. Rauert, the use of numerous fragmentation markers were used to analyse samples for different polymers, including polyethylene through the use of alkenes of varying chain lengths. The fragmentation patterns were then evaluated with respect to a potential blood matrix effect through the use of a statistical univariate approach. When applied to blood samples, Dr. Nardella reported that NMPs were detected above the limit of detection in 102/102 blood samples, with 20% of samples greater than the limit of quantification. Polyvinyl chloride had the highest detection levels, ranging from 413-827 ng/mL, whereas the mean of the sum of the polymer concentration above the limit of quantification was 386 ng/mL. Given the relatively low concentrations detected in blood, more sensitive analytical methods are needed to assess internal exposure, such as high-resolution mass spectrometry. Lastly, understanding the variability within and between individual donors represents an important need, and is critical for better understanding variability of NMPs in humans.

Estimating the Internal Concentrations of MNPS by PBK Model

Ira Wardani

Following the technical presentations from Dr. Rauert and Dr. Nardella, Ira Wardani, a PhD candidate at Wageningen University working under the supervision of Dr. Koelmans, presented a summary of her progress on a Plastics Europe project related to the development of a human exposure probabilistic modelling framework for microplastic. Specifically, progress on the development of a physiologically based kinetic model was described. Given the detection of NMPs in various human tissues and organs, it is thus important to better understand their potential fate and distribution, whereby models can potentially be used to help identify the properties of particles most likely to be taken up and where they may accumulate in human tissues. The model developed thus far considers two different adsorption mechanisms, reflecting either a perfusion-based approach or a diffusion based approach. Depending on which transport mechanism is considered, accumulation in tissues is limited by either blood-flow (perfusion-based) or membrane-flow (diffusion), which are influenced by a different set of assumptions regarding transport between the blood and the tissue. A diffusion based approach, for instance, requires an assumption regarding the mass transfer of particles between the blood and tissues, which is based on an equilibrium assumption, whereas diffusion-limited models perceive tissues cell membranes as barriers that hinder particle uptake, requiring the use of mass transfer coefficients to describe transport between the blood and the tissues. Due to the assumption of equilibrium adopted in blood-flow limited models, their applicability is likely more relevant to small molecules. Thus, it may be anticipated that the diffusion-based approach may be better suited to NMPs.

Results from both modelling approaches were presented, utilizing the availability of data from inhalation exposure studies of fine particles (20 and 1000 nm). In this instance, an assumption is tested to investigate the utility of the perfusion-based approach to model the fate and accumulation of 20 nm size particles, with the diffusion-based approach likely performing better for the 1000 nm particles, and their ability to reach different internal tissues and organs as a function of time. Model results (g/tissue) were shown to be in relatively good agreement with measured data for these two particle size classes.

The sensitivity analysis of the model identified that the most sensitive parameters for the perfusion-based approach were the partition coefficients related to uptake and elimination mechanisms, such as the lumen-gastrointestinal tract partition coefficient, whereas the sensitive parameters in the diffusion-based model were the mass transfer coefficients between blood and tissues. Application of the model to simulate uptake and elimination of inhaled particles was shown to be in relatively good agreement with study data, with the elimination of the larger particles largely dominated via excretion through mucus and faeces and smaller particles excreted through the faeces and bile in humans. Next steps in the PhD project include the need to obtain more experimental data covering a broader range of particle sizes and application of the model towards a dietary exposure pathway.

Environmental Monitoring: Development of RSVP Tool to Support Sample Collection

Dr. Richard Cross

Moving from human to environmental exposure, Dr. Richard Cross (UK Centre for Ecology & Hydrology) presented a summary of the development and application of a representative sample volume prediction tool for monitoring microplastic particles in aquatic systems. An important component of this research aims to consider the size of a sample you need to collect in order to communicate a level of confidence regarding the representativeness of the environmental system being studied. When reviewing monitoring data of NMPs in environmental samples, for instance, data can be seen to range up to eight orders of magnitude. To evaluate potential environmental risk, robust methods are thus needed to obtain data that are both relevant and representative of the system being assessed. Various factors may influence the large variability in environmental monitoring data. Dr. Cross presented an analysis of data reporting NMPs in aquatic systems, considering the influence of sample size, particle size and sampling method with respect

to variability in concentration. A curious observation is reported, whereby sample size can be seen to correlate with concentration, with small sample sizes being typically aligned with high NMP concentrations, particularly those obtained from small volume grab samples. One possible explanation for this observation may be that groups reporting NMPs in small volume grab samples may be reporting smaller particle sizes than those groups obtaining large volume samples, such as through the use of nets or pumps. Analysis of the data with respect to particle size, however, only suggests a weak statistical relationship, with sample size representing the more sensitive parameter.

The tool developed and presented by Dr. Cross to help guide researchers towards collecting samples with a given level of confidence, utilizes a Poisson probabilistic distribution approach. The tool is put to two purposes: prediction of representative sample volumes and estimation of the sampling error associated with any measured concentration. The Poisson distribution, is shown to estimate the confidence intervals for samples in the absence of replication. This provides a screening assessment of significance between different samples. The confidence level that a researcher may be targeting, however, may differ depending on the purpose of the study. The lower the expected concentration in an environmental system, for example, the greater the sample volume needed to detect a single particle with increasing levels of confidence. Potential future applications of the tool presented include considerations for other matrices, such as sediment, soil, air and possibly biological tissues.

Reconciling Plastic Release: Modelling of Macro and Microplastic Flows to the Environment

Dr. Bernd Nowack

An important source of uncertainty when attempting to understand environmental and human health exposure is the need for improved characterization of the sources of NMPs to the environment. Dr. Nowack (Swiss Federal Laboratories for Materials Science and Technology) presented a summary of research that aims to characterize and quantify the flow of plastic from production to end-of-life, with an emphasis towards an improved understanding of the environmental fate of NMPs. Material flow analysis can provide a powerful approach towards characterizing the fate of plastic products used throughout society. Dr. Nowack has considered a range of different types of polymers used in commerce, representing nine product sectors, 40 product categories and 11 waste collection systems in different regions, including the EU, Switzerland, China and Japan. The resulting analysis produced 245 emission flows.

A notable observation from the research is that in Switzerland per capita peak plastic consumption can be seen to have already occurred around 2010, with consumption declining between 2010 and 2020. When evaluating the release of NMPs to the environment it is observed that clothing products represent the most important source of release to both water and soil, whereas the largest sources of macroplastic to the environment are characterized by post-consumer processes and consumer bottles and other types of plastic packaging. With an appreciation for the sources of NMPs to the environment, Dr. Nowack presented estimates that suggest that PET represents the largest type of NMPs released to the environment with respect to mass, with an emission factor of about 0.5% derived.

The life-cycle based approach adopted to estimate the environmental release of both macroplastic and NMPs was then evaluated for Switzerland, where it is observed that plastic release in Switzerland is estimated to be much less than for other regions. The release estimates were thus used to estimate environmental concentrations for Switzerland, where potential hotspots can be prioritized and an assessment of possible environmental fate processes evaluated. The modelling, however, is based on a number of crude assumptions and will benefit from additional future refinement, including a fragmentation element, linking soil and water compartments and consideration of the fate of different sizes of NMPs in both soil and water.

Mapping the Tire Supply Chain and Microplastic Emissions

Sya Hoeke

The final presentation as part of the first session on analytical challenges, exposure and emissions was from Sya Hoeke, a PhD candidate at the Open University in The Netherlands, who presented a summary of a research project aligned with mapping the tire supply chain and its tire microplastic emissions. Tire and road wear particles are commonly understood to represent an important source of particles to the environment. When considering the magnitude of the source, an important question is how to best implement mitigation measures that might help to reduce emissions of tire and road wear particles. The first step towards developing a mitigation strategy was to map the entire tire supply chain, its emissions and the different stakeholders involved, their roles and interdependencies.

A detailed evaluation of the supply chain, including an understanding of the raw materials used in the manufacture of tires, their distribution and use by consumers and end-of-life components provided important insights towards identifying key stakeholders. At the same time, input from multi-stakeholder discussions provide valuable information towards mapping the flow of materials from production to end-of-life. Emissions for The Netherlands were thus estimated for 2021, with significant fractions of tire wear particles being released largely to soil (81%), with the remainder going to surface water (19%). Similar to the material flow analysis presented by Dr. Nowack, the life-cycle approach enables the identification of hotspots in the supply chain, from which strategic mitigative measures can be efficiently implemented. A key observation from the activity is the importance of multi-stakeholder discussions to build trust and credibility between the different groups and to reduce the occurrence of fragmented knowledge that can potentially impede the implementation of effective mitigation. Future steps aim to consider other dimensions, enablers and barriers, which will include additional stakeholder discussions planned for late 2025.

International Organization Activities and Trade Association Projects

Following the technical discussions during the first half of the opening day, a number of presentations aimed at providing an opportunity to better understand activities being progressed by different stakeholders on the topic of NMPs, including international research groups, organizations and industry trade associations were given.

Scientific Challenges of Plastic Pollution in the Marine Environment: The Role of 'Imperfect' Definitions

Dr. Sergey Lyulin

Dr. Lyulin (Novgorod State University) initiated discussions by reflecting on the scientific challenges of plastic pollution in the marine environment, with a particular emphasis on the implications of an "imperfect" definition, both from a scientific and regulatory perspective. Recent activity at the international level towards establishing a treaty on plastic pollution, for instance, requires the availability of robust and reliable science that can effectively characterize both the hazards and exposure to NMPs for human health and the environment.

It should be recognized that plastic represents an important material, with a number of societal benefits, however, as the production of plastic continues to increase concerns regarding its environmental release warrants international action to reduce plastic pollution. Unfortunately, the term plastic is oftentimes incorrectly applied, from a technical perspective, with many environmental scientists failing to specify which types of polymers they include in their use of the term plastic. While all plastic are made of polymers, for example, not all polymers are necessarily plastic. For example, thermoplastics and thermoset plastics

represent materials that can be considered plastic, whereas elastomers, are not considered to be plastic, according to ISO 472.

In the context of microplastics, which are broadly defined as plastic particles <5mm in size, there is inconsistency with other technical definitions, such as ISO 24187, which refers to any solid plastic particle insoluble in water with dimensions between 0.001mm and 1mm, while the definition used by ECHA reports a maximum size of 5mm. Lastly, some high-profile publications have included pigments of paint as part of their definition of primary microplastics, which is simply incorrect as paint pigments are not polymers but are comprised mostly of inorganic materials.

From a scientific perspective the environmental fate and effects of particles will differ depending on particle size. Particles in the nano-size range, for instance, are influenced by non-Newtonian physics, such as Brownian motion in aqueous solutions, whereas larger size particles will be influenced by Newtonian physics. The potential for particles to translocate across tissues and their interactions with chemical contaminants are also strongly influenced by particle size. Consequently, the use of imperfect definitions, such as for microplastics as being all plastic particles <5mm, results in imperfect strategies to assess their fate, exposure and effects. Based on the available data there are no studies that have sufficiently demonstrated a human health effect associated with exposure to NMPs, with efforts aimed at assessing the role that NMPs play as vectors of chemical exposure failing to appreciate the role that other organic particles represent as vectors of exposure and chemical fate. Interdisciplinary research is thus needed to address the complexity of the issues that surround NMPs, which must include polymer chemists and physicists, material scientists alongside analytical chemists and toxicologists.

Outcome From a Recent OECD Survey on Safety Testing of Nanoplastics

Dr. Eugene Choi

The OECD develops standardized test guidelines and guidance documents to support safe testing and management of industrial chemicals. In the context of microplastics, the OECD have activities related to policies to reduce microplastic pollution in water with a focus on the release of particles from textiles and tires. Other activities include chemical management and mitigation polices aimed at supporting the sustainable design of plastic and circular economy ambitions.

The next steps for the OECD are to consider the role that the OECD may play in safety testing and risk management of nanoplastic particles, which as a first step would require the development of a scientific standard that can be used to establish a harmonized approach with relevance and reliability. Dr. Choi summarized several OECD test guidelines and guidance documents that already exist or are under development for nanomaterials. It may be that many of these could be applied to nanoplastics. To initiate discussions aimed at clarifying the role that OECD may play in supporting the safety testing of nanoplastics, a workshop is planned for 12-14 November 2025, which will build upon a survey that was circulated among OECD member states, BIAC and other organizations. It is clear from the initial survey that there are a number of scientific and technical challenges, such as limited availability of reference materials for nanoplastics. The lack of standard materials limits the ability to compare results generated by different groups using different types of poorly characterized particles, which hinders the uptakes of scientific data for risk management of nanoplastics. Consequently, providing technical guidance on the issues surrounding nanoplastics may represent an important opportunity for OECD to provide leadership on the topic, which can potentially help support the generation of robust, reliable and relevant data.

Microplastics and Chemicals in Plastics: Perspectives from the Basel, Rotterdam and Stockholm (BRS) Conventions

Dr. Kei Ohno Woodall

Dr. Ohno Woodall (Senior Programme Management Officer, Secretariat of the Basel, Rotterdam and Stockholm Conventions) gave a summary of the interactions between chemicals and plastics, based on a perspective from the Basel, Rotterdam and Stockholm Conventions. It can be generally understood that plastic pollution represents a source of concern for all stakeholders, and recent action at the international level to develop a legally binding instrument on plastic pollution represents an important step towards addressing an issue of growing concern. Language drafted in the INC-5 text, for example, includes the possibility to include reference to plastic products that contain intentionally added microplastics, measures to improve plastic product design that will help to minimize the release and leakage of plastic, including microplastics, into the environment and provisions to prevent the generation of secondary microplastics by avoiding mismanagement practices, such as open dumping, burning and ocean waste disposal.

Several Multilateral Environmental Agreements, however, do exist, including the Basel, Rotterdam and Stockholm Conventions, which include measures that can also be used to address concerns associated with plastic waste and plastic associated chemicals. For instance, the Basel Convention includes measures to prevent and minimize plastic waste through the adoption of environmentally sound management practices, such as prior informed consent procedures for the control of transboundary movements of waste. Whereas the Rotterdam Convention includes prior informed consent procedures for the trade of chemicals and the Stockholm Convention aims to control the production, use, import, export, waste and unintentional release of persistent organic pollutants. Most recently, in 2022, the POPs review committee concluded that the plastic additive chemical, UV-328 is likely, as a result of its long-range transport, to lead to significant adverse human health and/or environmental effects, such that global action is warranted. Moving forward a key challenge under the various Multilateral Environmental Agreements pertains to an improved understanding of how chemicals are used in products, and which products contain which chemicals. The POPs Review Committee has most recently (October 2025) established a working group on POPs in products and articles to evaluate the extent to which the challenge might best be addressed.

Brigid: Progress and Horizons

Dr. Erik Rushton & Dr. Clementina Vitali

Next, several presentations summarized activities being undertaken by various industry trade associations. Representing Plastics Europe, Dr. Clementina Vitali (Plastics Europe) and Dr. Erik Rushton (LyondellBasell) gave an overview of research supported by the Plastics Europe Brigid project. The Brigid project is a multimillion project that aims to support the generation of open and transparent science, the objective of which is to enable an assessment of the human health risk related to the ingestion of NMPs. The project includes 6 work packages, running between 2022-2027, covering various aspects of the issue, including reference materials and analytical method development, exposure and hazard assessment, application of the data to generate a risk assessment and outreach and dissemination activities. To date, the project has resulted in the generation of different types of test materials and is working towards best practices regarding how these materials can be used to support toxicity testing. The assessment of exposure has been supported by the development of a combination of complementary projects, including the development of in silico tools, in vitro models to assess transfer across biological membranes and in vivo studies, such as the quantification of NMPs in human stool and considerations aimed at evaluating possible relationships between diet and concentration. Similarly, evaluating the potential hazards associated with test materials generated are planned to be explored through a combination of in vitro, ex vivo and in vivo studies through 2025-2027. The end results are anticipated to be a probabilistic distribution function-based exposure model, supported by improved understanding of translocation of particles across membranes and a risk assessment framework by 2027.

CEFIC Long-Range Research Initiative Update

Dr. Katherine Santizo

Complementing the activities supported by Plastics Europe are several projects being funded by the CEFIC-LRI programme. Dr. Katherine Santizo (LRI Programme Manager) communicated the ambitions at CEFIC towards helping to fill various data gaps related to the issue of NMPs. In 2021, CEFIC launched a programme as part of the ICCA global initiative (MARII), with a budget of 6 million over 6 years to support relevant research. To date, the activities supported by CEFIC have resulted in 12 publications and three open-sourced tools that have been developed from 15 separate projects, which aim to address issues related to the fate of NMPs in the environment and human health. Similar to the Plastics Europe Brigid project, the objective of the research supported by CEFIC is to develop user-friendly risk assessment models that can be used to characterize and quantify the risk of NMPs in the environment, the aim of which is to support science-based decision making by regulators and the scientific community. Next steps are to continue supporting additional research sufficient to support the assessment of the risks to humans and the environment, and to actively collaborate with various ongoing efforts, such as those at EU RTD, JRC, and the MOMENTUM project.

Japan Chemical Industry Association (JCIA) Research Update

Dr. Takashi Mori & Dr. Yoshifumi Horie

Providing an update on activities supported by the JCIA-LRI programme, Dr. Takashi Mori gave a summary of efforts aimed at assessing the sources, emissions and environmental risk of microplastics to support risk reduction strategies. These efforts are further supported by research that include the preparation of standard microplastics, and ambitions to test microplastics following new proposed test guidelines for ecotoxicity testing and a quantitative assessment of translocation mechanisms of microplastics across fish membranes using a novel digestive tract method. A detailed summary from a JCIA-LRI project related to the ecotoxicological risk assessment of microplastics in Osaka Bay was presented by Dr. Yoshifumi Horie (Kobe University).

The purpose of the research presented by Dr. Horie, supported as a JCIA-LRI project, is to evaluate if the microplastic in Osaka Bay represent a risk to the ecosystem. To support the assessment Dr. Horie summarized results from a feeding experiment with different types of fish, the objective of which was to assess if different types of fish show selective preferences towards ingesting microplastics of specific colours. It was observed that Clown Anemone fish exhibited a preference towards red, yell and green microplastic particles. Next, ecotoxicity studies were conducted using microplastics sampled directly from Osaka Bay. It was generally observed that non-plastic particles dominated the samples collected. Consequently, ecotoxicity tests were designed to test the specific microplastic particles collected from Osaka Bay in 2023 on Japanese medaka, with an intention to compare results against other naturally occurring particles, including pollen and volcanic ash, as well as a positive group using 3.2 mg/L of bisphenol A. Tests were conducted according to OECD TG240, with a range of test concentrations (i.e. 1-100 mg/L) using polypropylene at a particle size of approximately 0.1 mm. Preliminary results reported imply no adverse effects in fish after long-term exposure, despite evidence of ingestion.

Systematic Review of Potential Developmental and Reproductive Toxicity of Microplastics

Dr. Robert Ellis-Hutchings

It is evident that evaluating the toxicological hazard of NMPs represents an important and continuing research goal by many researchers, where both ecotoxicological and human health risks are needed to support regulatory decision-making. Dr. Robert Ellis-Hutchings (Dow) provided a summary of an ACC supported project that systematically reviewed studies reporting on the developmental and reproductive

toxicity of microplastics. The general consensus from various organizations, including the World Health Organization, the U.S. Food and Drug Administration and the German Federal Institute for Risk Assessment is that the current scientific evidence is not sufficient to demonstrate that current exposure to NMPs represents a risk to human health, largely due to a lack of availability of reliable data. Nonetheless, there is a significant acceleration in the number of studies being generated, as well as numerous efforts aimed at evaluating the quality of those studies, with some evaluation tools representing a Tier 1 screening level of evaluation. When attempting to consider complex endpoints, such as developmental and reproductive toxicity, there is a need for Tier 2 evaluation tools. Dr. Ellis-Hutchings suggested that the OHAT risk of bias tool developed by the U.S. National Toxicology Program could be used to provide an assessment of bias in study design. Specifically, bias represents a systematic error, or deviation from the truth, in results or inferences, which can lead to either an under- or overestimation of the 'true' effect. Consequently, a Tier 2 evaluation tool was developed and applied to developmental and reproductive studies identified through a systematic review of the literature, which report a relevant toxicological effect for NMPs.

Based on the literature review and evaluation performed, it was observed that no study reporting on developmental and reproductive toxicity was sufficiently reliable to be sufficient for use in evaluating human health risks. The major shortcomings identified across studies related to an inconsistent exposure characterization, poor outcome assessment and lack of adherence to validated test guidelines. To strengthen reliability and reduce bias, a number of recommendations were presented, including the need to use environmentally relevant test materials, which should be fully characterized, confirmation of delivered dose, along with an assessment of the stability of the dose throughout the experimental test, and other key parameters communicated to support study replication.

Communication's Role in Microplastics Research

Matthew Kastner

Given the breadth of activity covered during the first day of the MARII Summit, Matthew Kastner (American Chemistry Council) ended the opening session with a brief message on communications. Given that MARII represents a global platform for scientific exchange to advance research on microplastics, researchers should be aware that the platform can facilitate communication of their research, and were thus encouraged to reach out to Mr. Kastner, or others involved in MARII, to take advantage of communications support.

Day 2 – Thursday 16 October

Activities by Stakeholder Organizations and Regulatory Implications

The second day of the MARII Summit kicked off with a summary of the presentations given on the first day by Dr. Todd Gouin (TG Environmental Research), which was then followed by presentations from several key stakeholder organizations. The objective of this session was to thus provide an opportunity to learn about activities from different stakeholders and to provide potential networking opportunities, an important aim of which would be to potentially identify complementary activities that could support and advance scientific understanding of the exposure, hazards and risks that NMPs represent to human health and the environment.

The Generic SPM-Tonnage Estimation Methodology – The FEICA Case

Dr. Thorsten Wind

Dr. Thorsten Wind (Henkel) opened the session with a summary of European regulatory activity, specifically related to Commission Regulation 2023/2055 entry 78 of Annex XVII (enforced October 2023). Of particular interest is the scope of the restriction which targets synthetic polymer microparticles (SPM). These are defined as solid, water-insoluble, non-biodegradable particles smaller than 5 mm (or <15 mm for fibers) that must not be placed on the market as substances on their own or in mixtures at concentrations ≥0.01% by weight.

As of 2027, industry is required to report releases of SPMs from products into the environment on a yearly basis per legal entity. Dr. Wind presented an estimation approach that can offer a practical solution for harmonizing the environmental emission reporting of SPMs across organizations. The proposal builds on the concept of Specific Environmental Release Categories (SPERCs), that were developed among industry representing environmental modelling parameters for environmental exposure assessments for several substance uses under REACH. For SPM uses that are derogated (e.g., in adhesive and sealant products or during industrial uses), the primary release pathway is down-the-drain. Given the relatively high removal efficiency of wastewater treatment systems for microplastics, the two relevant environmental compartments are water and soil—the latter due to biosolid sludge application to fields. In addition to SPERC release rates of the uses, the sewage treatment performance and the fate of biosolids (agricultural application or incineration) are considered, which varies across EU member states. Hence, this variability can have considerable impact on the reported environmental emissions per legal entity.

The development of the estimation concept is being advanced by FEICA, with an ECETOC Task Force currently working on illustrative case studies. The aim of this Task Force is to publish the concept in a peer-reviewed journal to gather a broad acceptance between industry and regulators.

Tyres and Road Wear Particles

Dr. Adam McCarthy

Representing the European Tyre and Rubber Manufacturers' Association (ETRMA), Dr. Adam McCarthy articulated the importance with respect to vehicle performance. Due to the functional use of tyres, they are subject to wear, which intuitively causes them to shed particles as a result of the friction between the tyre and the road. Several important factors, however, influence the extent of wear, including driving behaviour as well as road and vehicle characteristics. Typical tyre and road wear particles (TRWP) are known to be characterized by elongated particles, which are a mixture of tyre and road pavement materials and are primarily in the PM10 size range (diameter of 10 µm to greater than 2.5 µm). Regulation (Euro 7) sets a

framework to translate into EU law the tyre abrasion limits that will be established at UNECE level, and will require testing on new C1 (passenger car tyres) tyre types. Importantly, Euro 7 will establish a non-exhaust emission related to the wear of tyres for the first time, and will allow a comparison between tyres on the EU market against results for C1 tyres at the UN level, thus supporting a global regulatory framework that will help to prevent future trade barriers. Euro 7 will regulate tyre abrasion for all tyres being placed in the European market. Test limits for C1 tyres were adopted in February 2025 in UN GRBP, and by 2026, EU regulators will decide on C1 tyre abrasion limits base on an assessment of the market.

Microplastics Community of Practice

Ruchi Shah

The International Life Sciences Institute (ILSI), represented by Ms. Ruchi Shaw, is also engaged in a number of microplastic-related activities, supported by the ILSI Europe Microplastics Initiative. ILSI supports the food sector through the development of science-based guidance that aims to ensure the safety of foods and beverages for consumers. Ms Shaw gave an overview of the ILSI scientific portfolio, which includes new approaches for food safety, food allergy, food packaging, food-related contaminants, microbiome as well as components of nutrition, development and healthy aging. There are several ILSI Europe task forces that are currently active in supporting science-based decision making. Given concerns related to the presence of NMPs in foods and beverages, either directly or as released from food packaging materials, ILSI has aimed to better understand the implications that exposure to humans may represent. Within this context the ILSI Microplastics Initiative has launched a multidisciplinary community of practice to support the exchange of scientific knowledge and the latest advancements in the field of NMPs. Recognizing that exposure characterization of NMPs in complex matrices, such as represented by foods and beverages, ILSI is planning an in-person workshop on the topic of analytics for 21st January, 2026, the objective of which is to better understand the latest advances and continuing challenges.

Convening Industry-Wide Innovation to Reduce Microfibre Pollution

Elliot Bland

Mr. Elliot Bland, a researcher from the Microfibre Consortium (a non-profit, science-led organization), discussed the environment impact of microfibres. Numerous studies have reported the presence of fibre fragments (both cellulosic and synthetic fibres) in various environmental samples, with links to harm in aquatic species. While the effects on humans are still under investigation, concerns over long-term, complex, and generational impacts persist. In his presentation, Mr. Bland shared information on the mechanistic causes and factors that influence fibre fragmentation. It has been observed, for instance, that natural fabrics like cotton, tend to shed more fibre fragments than synthetic fabrics. Additionally, staple yarn fabrics, knitted fabrics, and dyed fabrics generally shed more than filament yarns, woven fabrics, and undyed fabrics. Furthermore, specific design choices, such as hydrophilic finishes and mechanical finishes, can also impact fibre fragmentation. There are currently test trials being carried out to better understand the influence of finishes on shedding. Information that is generated is being collated from across the industry and being used to create a Microfibre data portal. Ultimately, there is an ambition that the information gathered across the industry can be used to identify effective strategies that can be used to help reduce the extent of fragmentation losses, but also to better understand the role of existing infrastructure to reduce the release of microfibres in manufacturing.

Analytical Method Development and Application to Food and Beverages

Dr. Eva Vizsolyi

Returning to the challenges of analysing NMPs in complex matrices that were touched upon during the opening session, with an emphasis on food and beverages, Dr. Vizsolyi (OFI) provided an overview of research being progressed at OFI (Österreichisches Forschungsinstitut für Chemie und Technik), which is an independent, accredited, Austrian research and testing institute that supports the areas of material testing and applications, recyclability and building renewal. Currently, OFI is part of an international project (MICROPLEXFOOD) that aims to assess the presence/absence of NMPs in complex food matrices and to identify the potential sources of contamination. The project began in October, 2023, and is due to end June, 2026. An important role for OFI has been aimed at developing sample preparation methods to support the analysis of NMPs through a combination of FTIR, Raman and pyrolysis-GCMS methods. An important observation by Dr. Vizsolyi relates to the time needed to digest and prepare samples for analysis, which can range from between about 5 days (e.g. milk) to 18 days (milled black pepper). Furthermore, the time to develop sample preparation methods was also communicated, which can involve several months of trial-and-error before a method is fit-for-purpose. The overall resource required to develop and generate data, therefore, should not be underestimated when developing a strategy to better understand the presence of NMPs in foods and beverages. Complementary to presentations given during the opening session by Dr. Rauert and Dr. Nardella, Dr. Vizsolyi also emphasised the importance of good laboratory practices, requiring strict adherence to quality assurance and quality control procedures, as well as with respect to the strengths and weaknesses of the various analytical methods.

Insight from the project, however, was shown to provide support with respect to mitigation strategies that could be introduced to reduce exposure to NMPs. As an example, Dr. Vizsolyi presented results based on the production of fruit juice, which had concentrations of NMPs in juice concentrate on the order of about 80 particles per sample, which were then reduced to <10 particles per sample in the end product. While polyethylene represented a major component of polymeric materials in the concentrate, it was largely eliminated from the final product. As a general observation it was anticipated that food packaging represented a relatively small source of exposure, as compared to other sources during the production process.

Next steps in the MICROPLEXFOOD project are to develop methods for bread rolls and turbid beverages. It is clear that in order to support an assessment of exposure to NMPs in foods and beverages that harmonized/standardized methods will be needed. As with presentations given during the opening session, relevant reference or test materials are needed.

Challenges in Microplastics Standardisation

Dr. Korinna Altmann

Following on the topic of standardization, Dr. Altman (BAM) articulated the importance of analytical method standardization and its role to support regulatory decision-making. Reliable data generated on NMPs, for instance, are needed to address the various concerns that have been raised regarding exposure of NMPs in the environment and to human health. Adherence to standard methods represents the most effective approach towards producing reliable information. Standardization, however, requires that methods be sufficiently validated, which requires that the method be tested against appropriate reference standards. Currently, there are several ISO standards that can potentially play a role, including ISO 16094-2:2025, ISO/DIS 16094-3 and ISO/WD 25654.

Within the context of standardization, reference materials play a critical role, which are needed to support an evaluation of a number of endpoints, including in the area of toxicology, instrument calibration, instrument development and sample preparation. To this end, Dr. Altmann gave an overview of activities at BAM aimed at generating reference materials to support their efforts to develop standard methods. Currently, cryomilling represents the most common technique to generate test materials, which BAM has used to generate non-aged PET and aged polyethylene particles of varying size. Based on their experience

generating and using test materials, BAM has observed that the most effective approach to dose the materials into a water sample, for example, is by creating a tablet having a known mass and quantity of particles. The tablet has been observed to produce a test material that is easy to handle, store and transport.

The tablets have since been used to support interlaboratory comparison studies related to the analysis of microplastics either by FTIR, Raman, TED-GCMS or pyr-GCMS. The interlaboratory exercise supported by BAM included 85 participants from across the globe, who were provided 6 samples (each 2 tablets, polyethylene and PET) plus blank samples. The study therefore aimed to evaluate the precision and accuracy of labs with respect to plastic number concentration and mass concentration of the individual labs and lab-to-lab variation. Results using either TED-GCMS and pyr-GCMS were observed to be generally similar with respect to reproducing mass-based concentrations for both polyethylene and PET. For the different spectroscopic methods, however, there were some notable differences, with higher particles numbers being reported when using Raman as compared to FTIR and a general observation of more scattering between labs when considering particle-count concentrations as compared to mass-based approaches. Overall, the research activities at BAM represent a fundamental element towards supporting the research community towards generating reliable and accurate measurements.

Development of Environmentally Relevant Microplastic Reference Materials

Dr. Oskar Hagelskjær

The final presentation in this session was given by Dr. Hagelskjær (Microplastic Solution) who continued on with the theme of environmentally relevant reference materials for microplastics. Defining environmental relevance, however, can depend on the specifics of the environmental matrix being studied and the method used as part of the analysis. Cosmetic products, for example, might consist primarily of a homogenous group of spherical particles that can be evaluated by FTIR, whereas for indoor environments a mixture of fibres may dominate the exposure, from which a range of methods could be used. Finally, other types of particles, including fragments and films can also dominate the types of particles identified in samples collected from the air, soil and sediment. A key activity at Microplastic Solution, therefore, has aimed to generate environmentally relevant reference materials, which are understood to represent a heterogeneous mixture of particles of varying polymeric composition, shape and size, using cryogenic milling. The generated particles are then characterized with respect to their particle size distribution and shape. To support their use in lab-based experiments, such as recovery tests for sample preparation methods, the use of specific polymers and specific colours can be advantageous.

When considering the recovery efficiency of microplastics, Dr. Hagelskjær also reflected on a potential relationship between particle size and recovery efficiency. For example, could it be that smaller size particles are subject to poorer recoveries than larger particles? Dr. Hagelskjær observed a potential increase in recoveries for smaller particles, which might suggest that sample preparation methods could be breaking down larger particles into smaller ones. Moving forward, there is a need to consider how to best simulate environmental degradation in the generation of environmentally relevant microplastics, which may also require consideration of the different types of plastic additives that may be in the plastic itself or chemicals that may be sorbed by the particles from the surrounding environment.

Microplastic Particles as Vectors of Transport for Hydrophobic Organic Chemicals

Dr. Todd Gouin

As noted in the final presentation of the previous session, there has been an increasing interest towards better understanding the role that plastic and NMPs may play as vectors of exposure for human health to both plastic additive chemicals and chemicals that may be sorbed by the plastic. To provide a top-level overview of the issue, Dr. Gouin (TG Environmental Research) provided a summary related to the mechanisms that influence the interactions between chemicals and plastic. It was noted that the role of

plastic particles as vectors of exposure was speculated upon in the first papers reporting microplastic in the environment in 1972, but only appears to have increased in concern more recently, following publications in 2007. When considering the role that NMPs play as vectors of exposure it is necessary to appreciate the mechanism that influences the interaction. For plastic additive chemicals that are non-covalently added to a plastic, for instance, the primary mechanism of sorption and desorption will be governed by the laws of thermodynamics. Effectively, organic chemicals are moving between different environmental media (air, water, soil, sediment, plastic, etc.) based on the relative differences in chemical potential between the different media until they reach a steady-state concentration in the environment. Plastic additive chemicals in plastic, consequently, are always leaching from the plastic products, causing us to already be exposed to the chemical prior to encountering a contaminated NMP. A holistic approach towards understanding our exposure to plastic additive chemicals is therefore needed.

Challenges in Plastic Risk Assessment: Exposure and Hazard of Particles and Additives

Dr. Roberto Rosal

Reflecting on the challenges in assessing the risk of NMPs, Dr. Roberto Rosal (University of Alcalá) summarized many of the key knowledge gaps. These include the need for accurate exposure information, which was suggested to be best represented as reflecting a mass-based concentration, which is lacking for small NMPs. Having detailed information about human exposure through foods and beverages would prove most advantageous. From a toxicological perspective, it is anticipated that only nanoplastic particles would be those that are most efficiently internalized, however, additional research is needed to better understand the biokinetic mechanisms of adsorption, distribution and elimination of NMPs. Evaluating the hazard of NMPs may be further complicated by the presence of chemical additives, non-intentionally added substances and the formation of NMPs from new types of products being introduced to the market, such as bioplastics. As a general observation, there is currently an insufficient level of information to enable an Bayesian-based risk assessment that could include an assessment of sublethal chronic effects and/or the influence of exposure to a combination of stressors.

Are Alternative “Bio” Plastics Chemically Safer Than Conventional Ones?

Dr. Ricardo Beiras

With respect to the question of the relative differences between ”conventional” plastic and bioplastic, Dr. Berias (University of Vigo) presented recent research that examined the ecotoxicity of NMPs originating from bioplastic versus other types of plastic. Biodegradable plastic, for instance, aim to address concerns associated with conventional plastics, which have the potential to persist in the environment and cause a myriad of impacts as plastic waste, in that if they are released to the environment they should degrade more rapidly, either from microbes or as a result of mechanical forces. The result is a material that would be more ‘friendly’ to the marine environment, should it unintentionally be released. The particles generated from bioplastics were thus evaluated in a series of ecotoxicological test systems, to provide an additional measure of their overall safety profile as compared against conventional plastic.

Products of similar types were thus identified from a range of polymers, including polyethylene, polystyrene and polypropylene and those from bioplastic, such as from PLA, PBAT, PBAT and starch, and those derived from a combination of PLA, PBAT and starch, and their potential to degrade evaluated. Mechanical degradation of the bioplastics was observed to be the most effective form of degradation, as compared to biodegradation as measured by the extent of mineralization. With respect to toxicity, polyethylene was observed to be innocuous to all marine test systems, whereas PLA showed no or very slight toxicity and PBAT-based items caused the largest toxic effects. A possible explanation for the slightly higher toxicity is tentatively identified as originating from various plastic-associated chemicals, represented by a higher fraction of ortho-phthalates. Thus, while compostable plastics may reduce environmental half-lives of plastic litter, they do not necessarily decrease the chemical risk caused by additive chemicals. A prior risk assessment is thus recommended to support industry to select safer chemical additives before placing them on the market.

Modelling Human Exposures to Plastic Additive Chemicals Via Microplastics

Dr. Mick Whelan

Moving from lab-based experiments to in silico tools, Dr. Whelan (University of Leicester) presented results from a study using a multimedia environmental fate and food web model (ACCHuman). The objective of the modelling study was to evaluate the relative importance of NMPs to act as vectors of exposure to plastic additives chemicals used in plastic, as compared to other possible exposure pathways. The approach presented aims to support an overall tiered approach, whereby relatively simple assumptions using a Tier 1 level of assessment might assume that 100% of chemical associated with a NMPs are bioavailable. Consequently, knowledge of the ingestion of NMPs, combined with maximum chemical concentrations and toxicological points of departure, can be used to derive a margin of exposure, consistent with the approach adopted in the 2019 World Health Organization report on microplastics in drinking water. The model presented by Dr. Whelan, however, adopts a Tier 2 level of assessment, which aims to consider the partitioning behaviour of chemicals in the environment as well as within an organism. Using a multimedia model, it is therefore possible to simulate the fate of chemicals between various environmental media, including between water, air, soil, sediment and organisms at various trophic levels. Coupling the multimedia environmental fate model to a food web model provides additional opportunities to simulate the fate of chemicals within a food web, such as their potential to biomagnify through the food web. Modifications made to the ACCHuman model aimed to include plastic as an additional compartment to which chemicals can either sorb or desorb, depending on the distribution of the chemical between the different compartments and whether the plastic is a sink or source of the chemical, which can also be ingested by organisms at all trophic levels.

Various exposure scenarios can therefore be considered in the model, the objective of which is to evaluate the sensitivity and uncertainty that NMPs may play as vectors of exposure to organic chemicals. The overall results suggest that for small NMPs (e.g. 0.001 mm) and relatively high exposure concentrations (e.g. >10 mg/d) where NMPs contain at least 5% (w/w) of the chemical in the plastic, that exposure to NMPs may represent a significant source of exposure. These exposure conditions, however, represent an extreme worst-case scenario, but when considering more environmentally relevant scenarios, it is unlikely that NMPs represent a significant source of exposure.

A Multidimensional Analysis of Human Exposure to Plastic Additive Chemicals

Dr. Li Li

Dr. Li (University of Nevada) gave a complementary demonstration of the utility of models with respect to their use towards better understanding the environmental fate and exposure to chemicals used in plastic products. Here, Dr. Li introduced the PROduction line To the Exposure levels model (PROTEX), which represents a holistic model that considers the release of chemicals throughout the whole life cycle of a consumer product. Humans are continuously exposed to chemicals, which are released from products at multiple lifecyle stages and through multiple exposure pathways, including inhalation, ingestion and dermal. Once released to the environment, for instance, chemicals can migrate from indoor environments to outdoor environments, where they can be transported long distances or deposit into aquatic or terrestrial environments and potentially enter the food web. Models such as PROTEX aims to thus simulate the fate and exposure of chemicals with respect to all of these various processes. Even given the large uncertainties regarding our quantitative understanding of human exposure to NMPs, it is possible to use the model to consider a number of different scenarios and to ground-truth various hypotheses against biomonitoring data of various chemical additives to consider the relative importance that NMPs alone may act as significant sources of exposure. Results presented by Dr. Li further support that when considering the more realistic exposure scenario presented by Dr. Whelan, that other sources of exposure to plastic additive chemicals are likely occurring, and there is thus a need to exploit and apply models to support a holistic exposure assessment of plastic additive chemicals for humans and the environment.

Plastic Additive Chemicals: A Critical Review of the PlastChem Report

Dr. José Kenny

Finally, Dr. Kenny (University of Perugia, European Centre for Nanostructured Polymers, and Novgorod State University) provided a constructive critical assessment of the Plastchem report, which reported on the state of science on plastic chemicals, the objective of which was to identify chemicals and polymers of concern. In their evaluation of the chemicals included in the PlastChem report, Dr. Kenny, however, drew attention to several inconsistencies and questionable entries. For example, common table salt, a commonly used chemical that is ubiquitous in the environment is listed as a chemical of concern, whereas in about 10% of instances the name identifiers are blank, making formal identification difficult to verify. When this was attempted in one instance, the CAS number for the entry was found to correspond to Aroclor 123 (or PCB1232), which is a mixture of polychlorinated biphenyls (PCBs), not a single chemical. Importantly, PCBs are listed on the Stockholm Convention on Persistent Organic Pollutants, and are therefore already flagged as chemicals of concern. Based on these preliminary observations, and following a more thorough review of the list of chemicals of concern identified in the PlastChem report, resulted in Dr. Kenny making the following observations: 1) Inconsistencies with the methodology of data collection, which resulted in technical errors in the chemical composition, structure and name of the chemical; 2) a lack of information regarding the degree of leaching of chemicals of concern from plastic, important for better understanding the relative importance of bioavailability and exposure; 3) the identification of duplicates in the list of chemicals of concern (5% of the list), whereby different physical forms of the same chemical are included in the list as different entries; 4) the presence of chemicals that are widespread in the environment, including silicon oxide, nitrogen (gas), sodium chloride, sucrose, lactic acid, vanillin and ozone, among others; and, 5) the presence of common mass-produced polymers, including polyethylene, polystyrene and polyvinyl chloride.

While the list of chemicals of concern, referred to as the Red list, draws attention to an important issue regarding the use of potentially hazardous substances, the list requires further in-depth analysis by independent experts, which would benefit from input by polymer chemists. In its current form the list fails to acknowledge the role of other current regulatory instruments, such as the Stockholm Convention, which can already be used to support international bans on the use of chemicals that represent a hazard to human health and the global environment. It is thus suggested that the global regulation of chemicals may be better served by the Bonn Declaration and the Global Framework on Chemicals, rather than a global agreement on plastics.

Day 3 – Friday 17 October

Plastic Additive Chemicals and Their Implications Within a Circular Economy

Similar to the second day of the MARII Summit, the third day began with a brief summary of the presentations given on the first day by Dr. Todd Gouin (TG Environmental Research), followed by a summary of activities that have been initiated towards better understanding the use of chemical additives in plastics, methods that exist to assess their risks, and the implications of plastic use and circularity.

ICCA's Plastic Additives Database

Dr. John Norman

Of particular interest is the development of a plastic additive database, supported by ICCA and presented by Dr. Norman (ACC). The objectives of the database include the desire to support chemical management capacity building in developing economies, provide an increased level of transparency regarding the use of chemicals, including plastic additives, and to support the assessment of risk by providing all stakeholders with tools and resources needed to inform risk-based management decisions. Following Phase 1 activities, 13,375 chemicals were identified, 86% of which have accessible toxicity data that can be used to inform a screening-level assessment of risk. After a thorough evaluation of the chemicals identified in Phase 1, Phase 2 of the database development verified that there are 4,549 plastic additive chemicals used in commerce, where 90% of chemicals have accessible toxicity data. Additionally, 89.2% of the 13,375 chemicals are listed on a regulatory inventory and 94.5% of the 4,549 chemicals used as plastic additives are listed on an inventory, with >70% listed on 5 or more inventories. Dr. Norman then provided details regarding how the database can be accessed and a short illustration of how to use the online tool and the types of information that can be accessed regarding the use of plastic additive chemicals.

CosPaTox – Safety Evaluation Guidance for the Use of PCR in Cosmetic and Detergent Packaging

Dr. Taryn Kirsch

The use of plastic additive chemicals in plastic products has also represented a potential challenge with respect to evaluating the safety of post-consumer plastic recyclates (PCR). Dr. Kirsch (Procter & Gamble) presented a safety evaluation framework developed by the Cosmetic Packaging Toxicology Consortium (CosPaTox). The framework presented aims to provide a strategy to assess the chemicals and their potential exposure and risk that may result from the use of PCR. Consequently, analysing the PCR represents a key component in identifying chemicals and their potential exposure. To evaluate the presence of chemicals requires the adoption of robust and reproducible methods, which was shown to be supported by a ring trial where different types of extraction solvents and conditions were used on PCR pellets generated for this study. It was observed that the pellets represent a reasonable and appropriate testing material to assess the presence and migration of chemicals. The analysis of the PCR pellets resulted in the identification of a wide range of substances, implying that the adoption of non-target analytical screening would provide a holistic approach to evaluating the extent of chemicals that might be associated with the PCR, as opposed to relying solely on a targeted analysis. Of particular interest is that the PCR materials were found to also contain substances not directly related to the packaging material, and which may have originated from food, filling goods or nonpackaging products in the recycling input. The implication of which is that there is a need for additional and more robust washing steps before using recycled plastics to eliminate or significantly reduce the presence of these other substances.

The framework guideline presented by Dr. Kirsch also includes a curated list of toxicological information for a large number of substances of interest and a worst-case calculation tool to evaluate the potential risk

for consumers. The key recommendations of the CosPaTox guideline are thus to first apply a combination of material characterization, safety assessment and quality management approaches that can be used to categorize materials, such as polyethylene and polypropylene recyclates into one of three quality levels, which are based on model packaging uses. Next, the chemicals present in the PCR must be evaluated to identify and understand chemicals that may migrate from the plastic into the product and to finally base decisions regarding the use of the PCR on a comparison of exposure with toxicologically derived threshold values. The work presented by Dr. Kirsch is now a DIN Standard (DIN SPEC91521), which is a recognized specification process developed by the German Institute for Standardization, and establishes rigorous quality, safety and performance criteria, which ensures that products and services comply with industry-leading standards. The CosPaTox guideline has been submitted to ECHA, which currently has a call for evidence for substances in packaging and packaging waste to support the preparation of a study report under the Packaging and Packaging Waste Regulation.

Additive Risk Assessment in a Circular Economy

Dr. Claire Doskey & Dr. Bjorn Hidding

As a complement to the CosPaTox guideline, Dr. Hidding (BASF) and Dr. Doskey (Dow) gave a brief update on an ECETOC Task Force related to understanding the use of chemical additives in plastic within the context of supporting a circular economy. As background to the topic, it is important to recognize that discussions on a UN Plastic Treaty have frequently referenced the use of chemicals associated with plastic as part of ongoing discussions, where it has been observed that both global plastic production and the (re) use of plastic is increasing. As noted in the previous presentation by Dr. Kirsch, there is thus a need for risk assessment frameworks to appropriately account for the presence of chemicals that may be present in the recycling materials and recycled feedstock. The objective of the ECETOC Task Force is to thus develop a framework that could fill the existing shortcoming and to describe how a risk-based approach can be used to support the use of plastic in a circular economy. Consequently, as in the CosPaTox Guideline, it will be necessary to evaluate the presence and amount of plastic additives that might be released when, where and how in order to assess their exposure potential, as well as any possible degradation products and the impacts that they may have on recycling and re-use. In order to inform a risk-based framework, however, the chemicals and their exposure must be considered in the context of their toxicity.

To this end, a risk prioritization matrix, that considers both human health and the environment, was presented. It is envisioned that the matrix will establish generic exposure scenarios for managed waste and recycling, such as through the development of environmental release categories, which can be helpful towards prioritizing mitigative actions regarding 'risky' uses while at the same time reducing uncertainty around low risk scenarios.

Chemical Recycling: More Pollution? Or a Sustainability Solution for Plastic

Dr. Todd Gouin

Finally, Dr. Gouin ended the session with a short presentation that aimed to stimulate a discussion regarding the adoption of different recycling technologies by summarizing a publication related to a debate titled "Chemical recycling: More pollution? Or a sustainability solution for plastic?". The published debate included perspectives presented by various stakeholders, including non-governmental organizations, industry representatives and academics. The debate can generally be summarized by placing proponents for advanced recycling as those who see an opportunity for the technology to help to support the use of plastic within a circular economy, whereas opponents to advanced recycling see the approach as being largely ineffective, raising doubts that the proposed benefits can ever be fully and completely realized. The summary of the debate presented was then used to stimulate discussion among workshop participants, asking individuals to reflect and comment on the strengths, weaknesses, opportunities and threats that advance recycling may represent.

While the strengths identified were generally supportive of perspectives articulated by proponents of advanced recycling, some of the weaknesses articulated related to a need for better clarifying the terminology and the different types of technologies that advanced recycling represents. It was noted that recent EU initiatives related to the development and application of a Digital Product Passport (DPP), which is a digital record that provides detailed information about a product's lifecycle, including its origin, materials, environmental impact and disposal recommendations, should represent an important opportunity that could help support the use of plastic within a circular economy. Tracking the source of the plastic, for example, 'virgin' plastic or whether the plastic originates from mechanical recyclate or from feedstock originating from an advanced recycling technology, can potentially be helpful towards better understanding the whole lifecycle of plastic and its role in the context of circularity. Intuitively, such insight would also be supportive of safe and sustainable by design. Threats identified relate to challenges associated with the collection and sorting of plastic waste. It was communicated, however, that advances in artificial intelligence and robotics represent important opportunities, which may help to address many of the current challenges associated with the collection and sorting, problems that opponents to recycling cite as representing significant impediments regarding the use of plastic within a circular economy.

An important observation was communicated in that it would be important to consider advanced recycling technologies as a complement to other recycling, reuse and reduce opportunities. For example, as a priority for many single use plastic, mechanical recycling could represent the first option to consider, with advanced recycling only being considered for feedstock that does not lend itself to mechanical recycling. Overall, advances in technological developments in plastic production and recycling should be considered holistically. There is thus a need for research activities to better demonstrate the added value of recent innovations.

Conclusion

Although the various topics discussed over the course of the MARII Summit identified a number of continuing challenges, the meeting closed on an optimistic note. Specifically, when considering the various advances in our understanding regarding the exposure and effects of chemical additives used in plastic, as well as the generation and sources of nano- and microplastic particles, this information can represent critical information towards supporting the generation and use of safe materials. The research presented during this MARII Summit thus provided an important instrument that brought together various stakeholders and researchers in helping to better understand how to best utilize the advances in scientific understanding within this context.