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Polymers, environment and sustainable developments: Opportunities and recommendations for the coming decade

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A MoDeSt Society Workshop entitled **'Polymers, Environment and Sustainable Developments Opportunities for the coming Decade'** was held in Albufeira, Portugal, during 30th April -3rd May 2017. The scientific programme of the workshop had eight Plenary talks, several oral and poster contributions and two Panel discussions which were led separately by two academics (Prof. S. Al-Malaika, Aston University, UK; Prof. P. Dubios, Luxembourg Institute of Science and Technology, Luxembourg) and by two industrialists (Dr P. Gijsman, DSM Materials Science Center, the Netherlands; Dr Haydar Zahalka, Addivant Global Technology, USA).

The note below gives an outline of some of the major points raised and discussed during the two Panel Discussion Sessions that highlight some opportunities and recommendations for the coming decade. We wish to encourage the Modification, Degradation and Stabilisation of Polymers (MoDeSt) Community to consider these points further and to contribute to these discussions at the forthcoming events shown below:

- MoDeSt Workshop, Pantelleria, Italy, 5–7 July 2017
- PDDG Conference, Taormina, Italy, 3–7 Sep. 2017
- MoDeSt Conference, Tokyo, Japan, 2–6 Sep. 2018

1. It is essential to have more effective interactions between academia and industry with the aim of achieving tangible contribution to the real-world/global issues that are within the activities of the MoDeSt society. An effective collaboration between academic leaders with industrialist and Governmental Bodies is critical if we were to attempt solving the most important societal challenges in the areas of health, safety, environment and the associated regulatory issues that are needed to accelerate innovation, exploitation and commercialisation, for new safe and environmentally-friendly technologies/products.
2. Greater opportunities can be realised for research-to-market outcomes when the research addresses directly some of the current pressing societal challenges and market demands. This includes, for example: health care technologies for an ageing population; food preservation; climate and the environment/reducing CO_2; energy conservation; innovative use of renewable resources to capture new markets; polymers/materials; waste management (including recycling, upgrading and re-use). This would potentially open up many niche opportunities for research and its applications in the field.
3. The polymer and additives industry compete openly in Global Markets so it is important to understand some of the issues arising from differences in legislations in different parts of the world, especially for industrially-sponsored research, so as to target correctly the research output for maximum market appeal.
4. The 'competition' between renewables *and* 'synthetics' should be viewed in terms of 'complementarity'. Parallel developments and innovations based on renewables and 'synthetics' could potentially deliver remedies/solutions for long-standing dilemmas. For example, it may be just physically impossible to replace all the large volume polymers in use today (obtained from fossil fuel, such as polyolefins) with polymers made from renewable resources. However, in the future, the market would benefit from parallel innovations

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that focus on renewable resources in order to reduce the pressure on the environment.

5. Society and industry have much vested interest in exploring further the potential of using renewable/green-resources for new polymers and additives. Fully-fledged academia-industry collaboration is imperative to identifying potential 'green' raw material candidates including availability, cost-effectiveness and efficacy (e.g. of additives) in polymers. New 'green' polymers and additives would only make it to the market place if they were to offer real overall benefits, i.e. based on unique and better set of properties, functionalities and performance (or cost-performance effectiveness) compared to existing commercial fossil-based products. Regulatory pressures are further key drivers to accelerating progress toward putting into place a road-map for alternative/parallel solutions so as to reduce our dependency on fossil fuel-derived polymers and additives.
6. Research undertaken would ideally be planned from its conception in such a way that it would lead to more sustainable solutions. For example, more focus on how to arrive at the desired outcome, including synthetic and up-scaling processes, by using some innovative green/sustainable chemistries/approaches rather than relying on existing 'tried and tested' methods and technologies.
7. The importance of Life-cycle analysis (LCA) cannot be overstated. Much research has been disseminated in the open literature which advocates the replacement of certain fossil-based polymers or additives by bio-based alternatives. More work is needed to quantify the specific benefits of proceeding with scenarios, case by case, backed by full LCA to assess the overall effects and benefits (tangible/intangible), i.e. cost, energy, health and safety and the environment.
8. Issues relating to polymer biodegradability warrant further studies. How important are biodegradable polymers and should these be targeted more toward specific applications, e.g. agriculture, medical? How to prioritise the different methods of polymer waste management technologies, e.g. recycling, re-use, incineration, in the light of Governmental and legislative directives. The looming problem of microplastics, the ultimate fate of degraded plastics and their effects on marine life and the food chain are challenging issues that need urgent attention to safeguard the well-being of future generations.
9. There was general agreement on the importance of fundamental research (blue-sky) particularly in academia, which is key to providing a lifeline/support to future advances and innovations in industry and technology.
10. It is important to recognise the contrasting, and to some extent conflicting, demands placed on researchers in academia and that of their peers in industry. Researchers in academia are assessed (e.g. for promotion) in terms of their research output - number, quality, impact factor impact of the research. A typical cycle for PhDs and PDRs is 2–5 years during which there is pressure to publish. This conflicts with the needs of industry which has a longer-term view of the work programme including innovations and protection of intellectual property, and this could lead to considerable time delays for publications. To circumvent such issues, academic leaders, in conjunction with their industrial sponsors, must have a long-term strategy for their research collaboration. Of course, this will require both parties to entering into a mutually beneficial agreement for a robust long-term commitment and support by both parties.
11. Addressing environmental and safety issues within research are of paramount importance. Examples discussed include designing-in products with recyclability in mind notwithstanding some intrinsic challenges, e.g. the case of designing recyclability in multilayer packaging (some contain up to 70 layers). Better understanding of the issues of recyclability and toxicity/health issues associated with polymer-nanocomposites warrants further concerted research efforts. The automotive industry does well with its in-house recycling and design-for-recyclability of parts; more could be done in other industrial sectors too.
12. Accurate lifetime predictions for polymers in their 'real-world' applications, require reproducible correlations between results from accelerated tests (e.g. accelerated/artificial weathering) and those obtained under application/service conditions (e.g. natural weathering). Greater insight into the physical and chemical factors, as well as the mechanistic aspects of the degradation of polymer-additive systems is required to better understand the underlying causes so as to factor in the differences often found between data obtained from Standards-based artificial weathering and exposures to those collected under real-in-service at different geographic locations.