Plastic post-Nairobi needs IUPAC involvement

Plastic pollution has been a serious environmental problem of global concern for quite some time. How to solve the problem was vigorously discussed at a UN conference in Nairobi, Kenya in March 2022, and before the assembly adjourned, an ambitious international agreement to end plastic pollution was concluded [1]. To reach this goal will be very demanding and require significant efforts from many, including IUPAC which is highly qualified to give independent advice.

by Leiv K. Sydnes

Soon after plastic became an important commercial product, plastic pollution became a major concern. Despite political focus and implementation of measures to stop the development, litter from plastic products continued to grow and reached an alarming level already some years ago. In many countries the plastic bag became the symbol for plastic garbage, and in Norway that proved to be a very appropriate pick when a sick goose-beaked whale stranded and appeared to have 30 plastic bags and other pieces of plastic in its stomach (Figure 1) [2,3]. This incident engaged the public in many countries, which quickly organized dugnads to collect plastic rubbish from everywhere—parks, forests and coastlines.

And there were lots to pick up. An abundance of products was found all over the place, particularly along the shores, and large quantities were collected for destruction. Gradually, this generated strong negative reactions to plastic in general and many calls for restrictions have been heard. Some groups of activists in several countries even talk about illegalizing the use of plastic. Such a reaction is quite surprising after more than two years with covid-19 have shown that plastic products have been instrumental in protecting us, securing safe and functional treatment at hospitals, and making simple test kits very easy to produce, distribute, and use.

To abandon all products made out of plastic without loosing significant benefits is of course impossible, but this does not mean that we can continue to use and treat plastic the way we have done in the past and do today. On the contrary, the negative environmental impact from plastics requires the implementation of powerful, sound measures so that the pollution is so much reduced that the total environment can function in a sustainable fashion [4]. The key to achieve this is efficient recycling, which probably is the single-most important action put forward in the international agreement passed in Nairobi, Kenya, in March 2022 to beat plastic pollution [1]. In order to reach the targets outlined in this ambitious document, four goals have to be met along the way.

Reduced use of plastic

The consumption of plastic is enormous and has to be reduced if plastic pollution is going to be curbed. Globally, more than 450 million tons of plastic is currently produced annually, and if the growth continues as now, the production will pass 1.100 million tonnes per year by 2050 [5-7]. Even if the plastic recovery increases to 95 %, which is almost an utopic level, such a consumption is not sustainable, and it is therefore necessary to reassess the need for all products containing plastic. The short-term goal must be to terminate the production of all products from which plastic can not be recovered and reused, in a sense somewhat like the REACH regulation, which makes it forbidden to use chemicals commercially if they don't pass a number of specific tests. Thus, the use of for example microplastic in creams and lotions like toothpaste and cosmetics must come to an end, and good methods for recycling must be in place before multicomponent materials containing plastic can be produced and used. A likely result from this exercise will probably be that the production of a variety of plastic types will have to come to a halt, and this will conceivably generate a need for development of new functional plastics that are degradable (see below).

Another measure that will contribute to reduced plastic production, is promotion of "circular approaches that give priority to sustainable and non-toxic re-usable products and re-use systems rather than to single-use products"[8]. The EU in particular is currently implementing such a policy, which will stop the use of plastic products that are typically used once or for a short period of time before being disposed of. This will for instance put an end to a variety of food and beverage containers, caps, straws, and lids, plastic bags, and plastic cutlery, but also to other products when non-plastic-based alternatives are unavailable [9].

Less littering

The plastic pollution problem is of course solved if the littering stops and existing waste in the environment is removed. To accomplish the latter is impossible, but to reach the former goal must indeed become a prioritized target. An important prerequisite for success is a more knowledgeable public, the idea being that better knowledge results in a more conscious attitude which leads to more recycling and less littering. Here IUPAC, through its Polymer Division (Division

Figure 1: A sick goose-beaked whale stranded west of Bergen, Norway, in 2017 and appeared to have the stomach filled with a large quantity of various plastic products; from ref. 2.

IV), Chemistry and the Environment Division (Division VI), Committee on Chemistry Education, (CCE) and Committee on Chemistry and Industry, (COCI) should aim at playing a more prominent role than it currently does by expanding and then actively promoting the home pages devoted to polymer education [10], education in material chemistry [11], and green materials [12]. Divisions IV and VI have a few current projects on plastics [13], but the associated information appear mainly to be devoted to chemists; with the exception of the green-materials site there is no informative material suitable for lay people at various levels, which is an important group of stakeholders to target in this context. IUPAC should indeed give priority to making these webpages more interesting and user friendly also for non-chemists and then inspire the Union's National Adhering Organizations (NAOs) to use the sites as resources for outreach activities, which many NAOs will need to launch national campaigns.

In most countries, the plastic recovery is very low [6]. There are several reasons for this misery, one being that people are discouraged and care less because collected plastic is not reused as indicated or even promised but destroyed in ways that affect the environment and the climate negatively. The emphasis on recycling, reuse, and circular economy in the Nairobi agreement is therefore an important message that quite likely will encourage the public to rally behind the initiative if national actions materialize.

To get a swift increase in the recovery of plastic, economic incentives must probably be introduced. In the circular-economy mind set, recovered plastic is litter from one industry but a resource for another. Locations for collection of recovered plastic should therefore be built, perhaps in connection with similar sites for collection of E-waste, which increasingly have proven to have a positive impact on the recovery of this sort of waste in countries like Kenya and Tanzania. The funding of such waste handling could be based on a duty on plastic products, which in part is converted to a deposit when recovered waste is delivered and collected.

Fewer types of plastic

The number of plastic varieties is enormous. The backbone is always a polymer, which is the basis for the international classification of the products (Figure 2) [14], but in addition there are all sorts of additives, such as antioxidants, colorants, softeners, and flame retardants, which optimize the plastic for its use. These additional chemicals vary a lot in structure, chemical properties, and toxicity, and this variation makes the recycling and reuse tedious and complex even when the plastic has been sorted perfectly according to the classification. Economic and

sustainable re-use of plastic therefore calls for a significant reduction in the selection of plastic materials and a more detailed labelling so that each of the seven main groups can be subdivided based on the additional chemicals and directly connected to the appropriate recycling process(es). In order to achieve this, an overall assessment of the additives, as pure substances and mixtures, has to be performed, and this is a task almost all divisions in IUPAC should contribute to.

Development of biodegradable plastics

But even if the measures discussed above are successful and will result in both lower consumption and a much higher recovery of plastic materials, littering of the environment will still occur. To reduce the impact of this pollution, the most stable plastics should be phased out and be replaced by new materials that undergo degradation (much) more easily. A lot of research is currently carried out all over the world to make this a reality, but particularly within the EU where the LIFE programme is the instrument for funding actions addressing climate and environmental challenges [15].

A green plastic bag made from the biodegradable and compostable material Biodolomer (from ref. 20.)

The key to success will be to make plastics that degrade relatively quickly and give compounds present in nature as degradation products. Such plastics are essentially of two types, biobased and biodegradable [16-19]. The former contains polymers made of raw materials of biological origin, for instance starch, proteins, and plant oils, which do not necessarily break completely down in nature, but since they are of natural origin and must pass strict tests before being used, the environmental harm is limited. The latter type has a polymer backbone made of raw materials that might have been produced from oil or natural gas, but their structures are such that when the plastics decompose, compounds already present in nature are formed. Some plastics of both types have been known for some time, but new and promising varieties are currently under development, for instance in the LIFE programme mentioned above and the NSF Center for Sustainable Polymers. The homepages for these programmes contain a lot of valuable information about many new materials, such as composites, granulated, biobased polyesters, and green plastics, which have properties that make them suitable for production of environmentally friendly alternatives to existing polluting products, for instance plastic bags [20].

To facilitate the industrial application of and product development based on these new materials, the documentation of their chemical, physiochemical, and mechanical properties should be critically examined and comprehensively reported. Search in the literature has not revealed any such document for biobased and biodegradable plastics, and this is a situation that could call for IUPAC action.

Postlude

Based on the agreement reached in Nairobi, the time has come to launch a global, sweeping campaign to remove plastic litter from the environment and stop this sort of pollution of nature. This littering is a classical example of a considerable societal problem where critically evaluated chemical knowledge and technology will play a key role to find solutions that are practical and sustainable. Historically, this is a sort of problem IUPAC has contributed to solving, and when the union's commitment to work for the implementation of the 2030 Agenda for Sustainable Development [21] is taken into consideration as well, active IUPAC involvement through appropriate divisions and committees should indeed be expected.

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PETE	HDPE	PVC	LDPE	PP	PS	OTHER
polyethylene terephthalate soft drink bottles, mineral water, fruite juice container, cooking oil	high-density polyethylene milk jugs, cleaning agents, laundry detergents, bleachingz agents, shampoo bottles, washing and shower soaps	polyvinyl chloride trays for sweets, fruit, plastic packing (bubble foil) and food foils to wrap the foodstuff	low-density polyethylene crushed bottles, shopping bags, highly-resistant sacks and most of the wrappings	polypropylene furniture, consumers, luggage, toys as well as bumpers, lining and external borders of the cars	polystyrene toys, hard packing, refrigerator trays, cosmetic bags, costume jewellery, CD cases, vending cups	other plastics, including acrylic, polycarbonate, polyactic fibers, nylon, fiberglass

Figure 2. Plastics are classified in seven groups; from <https://learn.eartheasy.com/articles/plastics-by-the-numbers/>.

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