Session: 3.07.P Beyond Microplastics: Analytics, Environmental Fate and Impacts of (Water-Soluble) Polymers and Biodegradable Polymers
Day: Thursday, 9 May 2024; 9:30 – 14:25
Room: Exhibition Hall (FIBES 2, FIBES)

Downscaling of syntheses and preparation of a variety of ^{14}C - labelled polymers and oligomers

D. Hennecke[1], M. Hüben[1], M. Kruse[1], B. Meisterjahn[1], E. Wischerhoff[2]

[1] Fraunhofer Institute for Molecular Biology and Applied Ecology, 57392 Schmallenberg, Germany
[2] Fraunhofer Institute for Applied Polymer Research, Department Sensors and Actuators, 14476 Potsdam-Golm, Germany
E-mail contact: dieter.hennecke@ime.fraunhofer.de

The use of ^{14}C-labelled substances in environmental studies is highly advantageous, because it enables the widely matrix independent detection of the parent substance and to follow resulting transformation products. While it is a well-established procedure for organic low molar mass compounds, it has rarely been applied for the investigation of environmental fate of polymers and oligomers, yet. This is mainly due to two principal challenges, first the necessary downscaling to the required small scale and second the selection and availability of the required ^{14}C-labelled monomers as the radioactivity might introduce undesired reactions of the often highly reactive monomers before the polymer synthesis starts.

Though there is no "off the rack" solution that suits for all polymers, it is possible to develop downscaling procedures for a variety of polymerisation processes and to circumvent problems related to the lack of availability of certain ^{14}C-labelled monomers. Examples for successfully synthesized substances will be presented, such as ^{14}C-labelled variants of cationic poly(acrylamide) copolymers, crosslinked calcium polystyrene sulphonate, propoxylated oligomers from a phenol-formaldehyde condensation and poly(ethylene). In each case the benchmarks for the ^{14}C-labelled polymers produced were the commercial non-labelled analogues to prove successful synthesis.

For the acrylamide copolymer, radical initiation induced by radioactivity had to be considered being a potential problem for the synthesis. The synthesis of crosslinked calcium polystyrene sulphonate required fine-tuning of dispersion polymerisation and sulphonation processes. Similarly, the synthesis of the propoxylated oligomers had to be adapted to appropriate pressure conditions in a lab-scale glass reactor to obtain an oligomer with a composition close to the commercial product. In case of poly(ethylene), a small fraction of the ethylene monomer needed to be substituted by an alternative monomer to introduce the ^{14}C-label while preserving the polymer properties, because ^{14}C-labelled ethylene is neither available nor suited for synthesis in a radioactive laboratory due to its physico-chemical properties.

^{14}C-radiolabelling offers a powerful option in the currently very challenging assessment of the environmental fate of polymers. The presentation intends to encourage industry and regulators to consider this technique for future testing of technically relevant polymers.