Eastman's position on the notion of "not chemically modified"

Eastman endorses the Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment, otherwise known as the Single-Use Plastics or SUP Directive (the Directive). The intent of the Directive is to prevent and reduce marine litter, however, it should be noted that the Directive has vulnerabilities that might delay the EU's transition to a circular economy. These vulnerabilities risk further perpetuating the linear economy and that future assessments of the aquatic environment will show that the amount of litter from single-use plastics is unchanged. In order to insure regulatory clarity and consistency with the Directive's objectives, we believe that a strict adherence to the definition of "plastic" is required, based on the reasons we elaborate below.

"**Plastic**" is defined in **Article 3(1)** of the **SUP Directive**: "'**plastic**' means a material consisting of a polymer as defined in point 5 of Article 3 of [REACH] Regulation (EC) No 1907/2006, to which additives or other substances may have been added, and which can function as a main structural component of final products, with the exception of natural polymers that have not been chemically modified".

This definition requires clarity of the notions of the terms "chemically modified" and "natural polymers". In this paper, we wish to draw attention to the fact that all man-man cellulosic fibres, such as cellulose acetate, lyocell and viscose, should be considered "chemically modified" and thus defined as "plastic".

REACH Regulation[1] Article 3(40) defines a '**not chemically modified substance'** to be: "a substance whose chemical structure remains unchanged, even if it has undergone a chemical process or treatment, or a physical mineralogical transformation, for instance to remove impurities." Chemical structure is more than simply the atomic structure of the repeating unit of the polymer.

- This requirement should be applied in a restrictive and precautionary manner, to ensure that the intent of the Directive, to reduce the impact of polymeric substances that can persist in the environment, is not undermined.

- This restrictive and precautionary approach is implied by the language of the Directive, with the terms 'unmodified' and 'not chemically modified' (recital 11), leaving no room for degrees of chemical modification – a natural polymer is either chemically modified or it is not.

- We reason that, when discussing a polymer, the term "chemical structure" must address both the composition and degree of polymerization. This is supported by the unambiguous language of the Directive and of Article 3(5) of REACH concerning the definition of what constitutes a "polymer".

- Further, we determine that the term "remains unchanged" requires that the structure was never changed, whereby any sequence of chemical modifications that change the structure, and then change it back during the process, does not pass this test.

[1] Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals

Given the unambiguous language of the Directive and of Article 3(40) of REACH, it seems clear that regenerated cellulose materials such as viscose and lyocell do not pass the test of being 'not chemically modified' as:

- Viscose undergoes clear, intentional and measurable chemical modifications to its structure during its manufacturing process including: 1) a reduction in the degree of polymerization, 2) a transformation to cellulose xanthate, 3) the creation of oxidative reaction byproducts, and 4) an irreversible transformation from the cellulose I to cellulose II crystalline morphology.
- Lyocell undergoes clear and measurable chemical modifications to its structure during its manufacturing process including 1) a reduction in the degree of polymerization, 2) the creation of oxidized structures on the cellulose backbone and 3) an irreversible transformation from the cellulose I to cellulose II crystalline morphology.

The dissolution of cellulose in the viscose and lyocell processes results in:

- A decrease in the degree of polymerization of cellulose involving the breakage of chemical bonds and is an attribute which is critical to the definition of the structural nature of a polymer.

- Chemical modifications during the manufacturing process that involve the breaking or creation of covalent bonds.

Depolymerization of cellulose involves the breaking of chemical bonds - It is worth emphasizing that the hydrolysis reactions that are known to occur during the dissolution, filtering and spinning of BOTH viscose and lyocell are well-documented and involve the breakage of covalent carbon-oxygen bonds and these reactions are irreversible[2] [3].

Chemical modification of cellulose - The manufacturing process involves the breaking and creation of covalent chemical bonds. In the case of viscose, the production of the xanthate ester involves the creation of new chemical bonds, and the hydrolysis of the xanthate ester involves the partial hydrolysis of these bonds [4][4]. In addition, there are numerous studies detailing the creation of new chemical structures on cellulose during the N-Methylmorpholine N-oxide (NMMO) dissolution and spinning, including the leading work documenting these chemical modifications published by Potthast and Sixta, and coworkers [5][5].

Furthermore, we would also note that:

- "**Regenerated cellulose**", the term used to describe material obtained by both the viscose and lyocell processes, have different EC (European Community) and CAS (Chemical Abstracts Services) identifiers.

- **Recital 11 of the Directive makes clear that:** "Plastics manufactured with modified natural polymers" are in scope and that "…plastics should cover polymer-based rubber items and bio-based and biodegradable plastics regardless of whether they are derived from biomass or are intended to biodegrade over time".

In line with the scientific evidence provided in this paper and cited literature, Eastman calls on the European Commission to ensure the creation of a level playing field for all man-made cellulosic fibres in its upcoming guidelines on the SUP Directive.

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