BIO-SOURCED MOLECULES IN THE RECYCLING OF PET

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INTRODUCTION

In the last decade, plastic recycling has become a priority for the sustainability of materials.[1] As stated by Helen Jordan from the British Plastics Foundation, "we need to stop thinking of plastic as 'waste', but as a renewable resource that needs to be disposed of correctly", as the recycling of plastics has the capability to save energy and to reduce resource consumption and waste. Polyethylene terephthalate (PET) is one of the most produced and used polymers, but still the main part goes in waste.[2] PET can be recycled by mechanical or chemical procedures. Chemical recycling includes hydrolysis, glycolysis, aminolysis, ammonolysis.[3]

In this work, bio-sourced molecules are used to give new life to post-consumer PET. In particular, mellophanic dianhydride, a homologue of the well known fossil-based pyromellitic one, is prepared from galactaric acid, and tested as chain extender for PET.[4] At the same time, by aminolysis of PET with serinol, a bio-sourced amine, a tetrahydroxylated diamide of terephthalic acid is obtained in a very efficient way, without the use of promoters, and proposed as branching agent for polycondensation polymers (Figure 1).

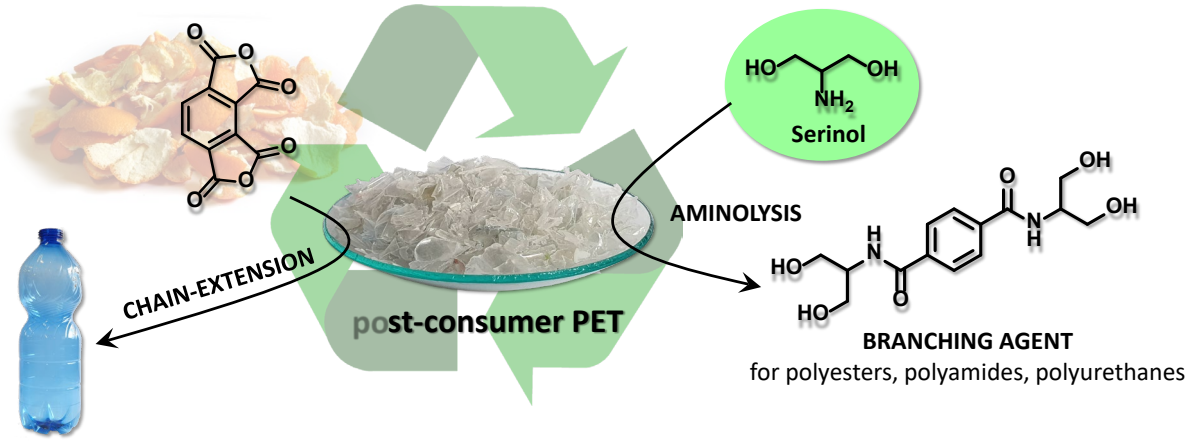
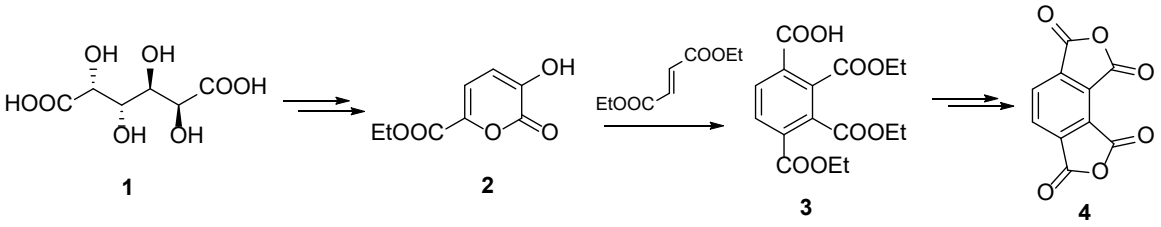


Figure 1 – general purpose

RESULTS AND DISCUSSION

Mellophanic dianhydride (**4**) was prepared through a multistep protocol, starting from galactaric acid (**1**). The reaction pathway includes: the formation of pyrone **2** from **1** by ring closure in the presence of acetic anhydride, a Diels-Alder cycloaddition to form the aromatic tetracarboxylic intermediate **3** [5,6], which is further hydrolyzed and dehydrated obtaining the desired dianhydride **4**.

Mellophanic dianhydride was then extruded with R-PET. Frequency sweep tests were performed showing an increase in the viscosity, a sign that PET increased its molecular weight (Figure 2a). A comparison of the performances of mellophanic dianhydride with respect to pyromellitic one (PMDA) was also performed. The complex viscosity tests showed that mellophanic dianhydride had the capability to improve the mechanical properties of R-PET almost as PMDA (Figure 2b).



Scheme 1 – Preparation of mellophanic dianhydride (**4**) from galactaric acid (**1**)

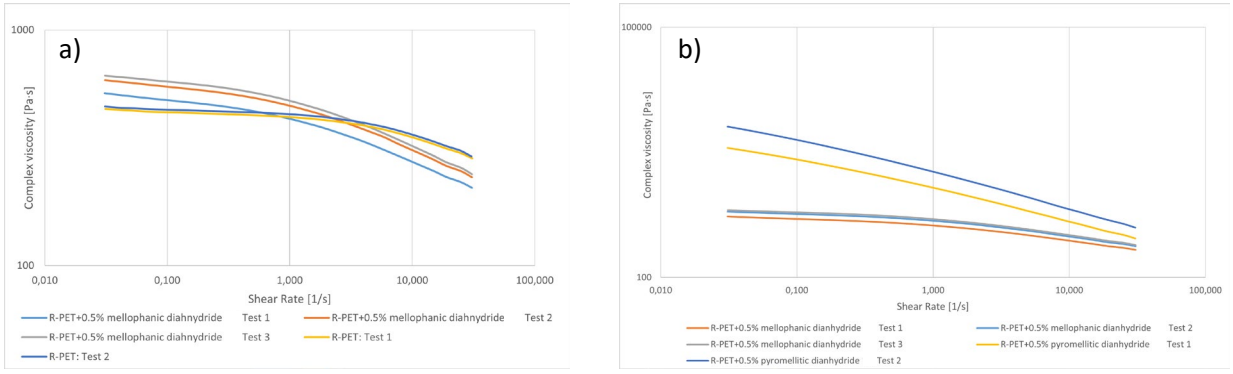
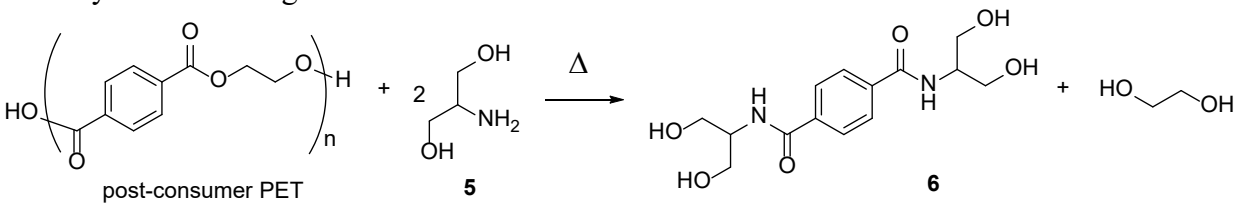


Figure 2 – a) Complex viscosity of R-PET extruded with **4**; b) Complex viscosity comparison of PET extruded with **4** and pyromellitic dianhydride.

The chemical recycling of post-consumer PET has been performed using serinol (**5**), a bio-sourced and non-toxic amine, in the absence of promoters, obtaining very efficiently the corresponding diamide of terephthalic acid (**6**) (Scheme 2). Its use as branching agent for polycondensation polymers is actually under investigation.



Scheme 2 – Preparation of diamide **6**

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