Solvent-based recycling towards recovery of TiO_2 from waste plastics

E.Carrieri[1], S. De Meester[1]

[1]Department of Green Chemistry and Technology, Ghent University, Kortrijk, 8500, Belgium
Keywords: polymer, titanium dioxide, solvent-based recycling, pigment, dissolution-precipitation technique.
Presenting author email: elisabetta.carrieri@ugent.be

Plastics have turned into essential goods in the industrialized world, reaching a global EU demand of 51.2 Mt. Unavoidably, such high production volumes translates in high volume of post-consumer plastic waste that has to be managed. For many years plastics had a linear production system, but a shift towards a circular one is now indispensable, as new regulations of different authorities prove (e.g. European Directive (EU) 2019/904).

Due to the broad spectrum of applications, and thus diversity of properties and compositions, plastic recycling presents many challenges. Multilayer structures are an example. Other compounds that complicate the recycling process can be found within the plastic itself: additives. Some additives have direct impact on the recyclability of plastics, both for mechanical (K. Pivnenko 2016) as well as chemical recycling. or even might support the degradation of plastic. One of the 4-additive types are colorants (Hansen, et al. 2013). Pigmented plastics when recycled tend to end up in dark-coloured material that have a much lower market value. Furthermore, when mechanically recycled, colour additives can result in an improper dispersion (due to migration), which can damage molecular bonds, or which can result in pigment agglomerates that defect the polymer matrix. Therefore the removal of pigments plays a key role in the upgrading of plastic recycling from an open-loop recycling system, to a closed one, in order to achieve the desired circularity of plastics.

In 2019, world pigments consumption was estimated to be between 8.5 and 9.5 Mt, of which 4.65 Mt for paint industry and 1.3 Mt for packaging plastics (Ceresana Market Research 2021). With 59% of world pigments consumption, TiO_2 is the most used pigment and it covers different polymeric matrix types: polyolefins (PE and PP), PVC (mainly for construction applications), engineering plastics for automotive and consumer goods (ABS, HIPS, PS) (RPA 2018). Titanium dioxide in fact, is even more expensive than the polymer itself. If one would be able to recover the TiO_2, this would significantly increase the economic added value of the recycling chain.

An option to recover the pigment is solvent-based recycling, referred to as physical recycling, which dissolves the polymer without depolymerisation, allowing to clean the polymer and/or recover components that were embedded in the polymer matrix (Schlummer, et al. 2020).

This work focuses on the recovery of TiO_2 white pigment from waste plastics, using the solvent-based recycling route. The overall process starts with the dissolution of the waste polymeric material in a proper solvent. A purification step follows the dissolution, during which the pigment is separated from the polymer-solvent solution, for example by filtration or centrifugation. This work will highlight both, modelling and experimental work, and compares the influence of different solvents in the separation step (e.g. filtration) related to aspects such as viscosity and particle size. It is shown that, interactions between solvent and TiO_2 surface have a strong impact on purification of the dissolved polymer. The interactions between polymer, solvent and TiO_2 were investigated with the support of COSMO-RS software which allows calculating the interaction energy between these compounds. Moreover, it is possible to study the contribution of the different types of interaction to the total energy (electrostatic, hydrogen bond, Van der Waals). This approach enables a science-based selection of the most promising combinations of solvent-TiO_2 grade, allowing the optimization of the purification step. The purified polymer is later recovered by the addition of a second solvent that acts as an anti-solvent for the polymer, and induces its precipitation from the solution.

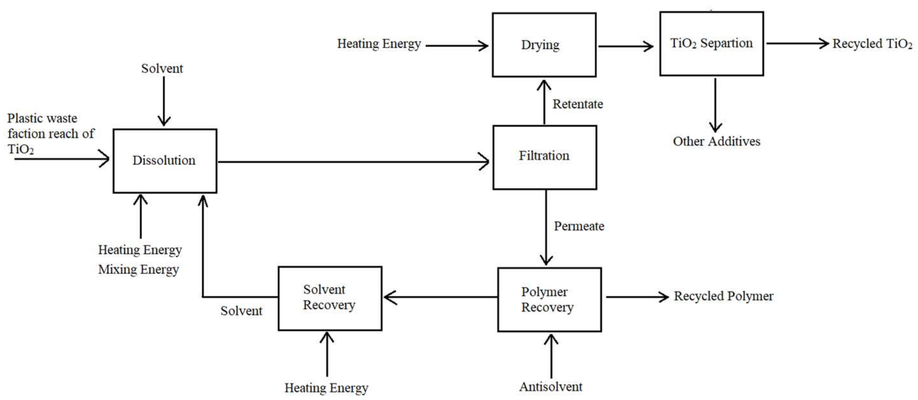

Figure 1. Schematic representation of solvent-based recycling process

This presentation will conclude by proposing a closed loop system for both, polymer and TiO_2 pigment, which would result in a more economic and environmentally sound solvent based recycling process for waste plastics.

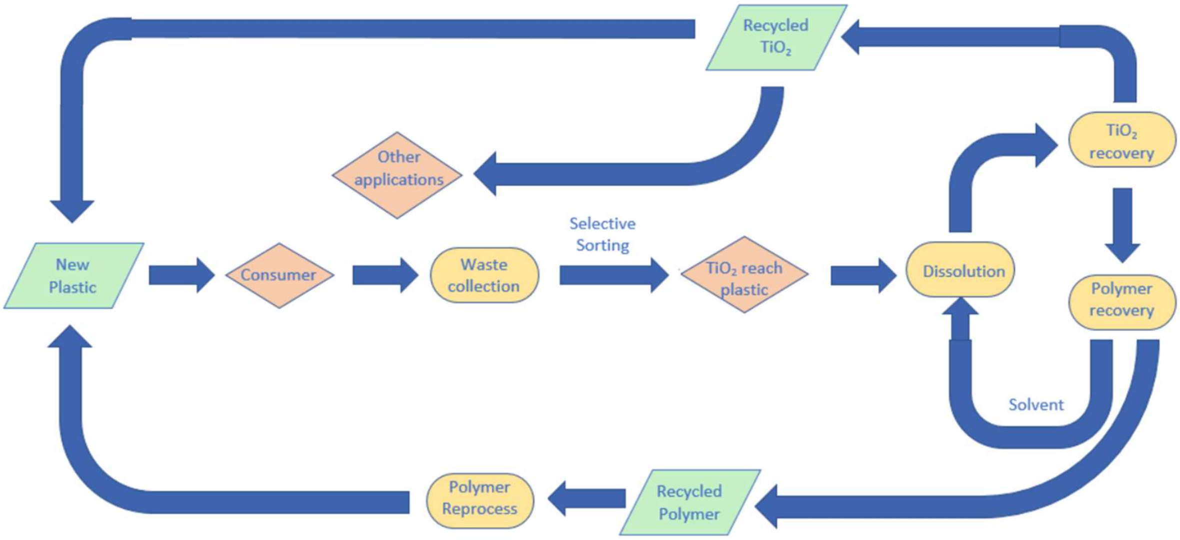

Figure 2. Possible closed loop system of TiO_2 pigmented plastics

<u>Acknowledgments</u>

This research has received funding via VLAIO, within the frame of the ICON Remove2Reclaim project.

<u>References</u>

Ceresana Market Research. "Ceresana sees world pigment demand passing the 11 M tonnes mark by 2027." *Focus on Pigments*, no. 2 (2021): 3-4.

Hansen, E., N. Nillson, D. Lithner, and C. Lassen. "Hazardous Substances in Plastic Materials." Danish Technological Institute, 2013.

K. Pivnenko, M.K. Eriksen, J.A. Martín-Fernández, E. Eriksson, T.F. Astrup. "Recycling of plastic waste: presence of phthalates in plastics fromhouseholds and industry." *Waste Manage* 54 (2016): 44-52.

RPA, Risk & Policy Analysts. "Risk Management Options Analysis for Titanium Dioxide (TiO2)." Titanium Dioxide Industry Consortium, 2018.

Schlummer, M., T. Fell, A. Mäurer, and G. Altnau. "The Role of Chemistry in Plastics Recycling." *Kunststoffe International*, July 2020: 34-37.