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Plastic Recycling Technologies should be compared based on true Facts

Without clear definitions there is the risk that too many people talk about plastic recycling without being able to compare different technologies and/or decide on which one should be preferred versus another. Since a couple of years it is undeniable that the World has a huge plastic waste pollution problem (...since more than 20 years) and big companies and organizations have started a competition on who saves the world as the fastest.

Actually, everyone splits plastic waste recycling into 3 technologies: Mechanical recycling, chemical recycling and energy recovery.

Solvent-based purification is typically described as chemical recycling, what may be explained by the fact that this cleaning technology has been used in the chemical industry for decades, but it was and still is a false and misleading classification.
The Solvent-based Purification is based on physical and not on chemical reactions/changes and only the physical state changes from solid to liquid and then back to solid. The polymer chains remain unchanged and can be ***re-used***.

Physical or Chemical Reaction?

Basics

A chemical reaction produces new substances, while a physical reaction does not.

A material may change shapes of forms while undergoing a physical change, but no chemical reactions occure and no new compounds are produced.

Physical Change

- **No new substance is formed**
- **No composition change**
- **The change is reversible**

Examples

- **Boiling water, melting ice**
- **Shredding paper (or plastic film)**
- **Dissolving sugar in water**
- **Melting a polymer** (e.g. extrusion)
- **Dissolving a substance in a liquid**

Chemical Change

- **New substances are formed**
- **Composition is changed**
- **The change is irreversible**

Examples

- **Burning wood**
- **Rusting of iron**
- **Polymerization & de-polymerization**
- **Pyrrolysis of polymers**

Please check:
Bozeman Science - "Chemical and physical changes":
https://www.youtube.com/watch?v=ziQtpXVDpn0&feature=youtu.be

Chemistry for Kids – "Chemical and physical changes":
https://www.youtube.com/watch?v=x49BtB5dOwg&feature=youtu.be

Zero Waste Europe

In October 2019 Zero Waste Europe published their study "Eldorado of Chemical Recycling"[1)] and describe solvent-based purification" as chemical recycling and explain that "the physical and thermal stress generated by this process decreases the average chain length of the polymer, affecting its quality. Solvent-based purification thus cannot be a perpetual recycling method for plastics".

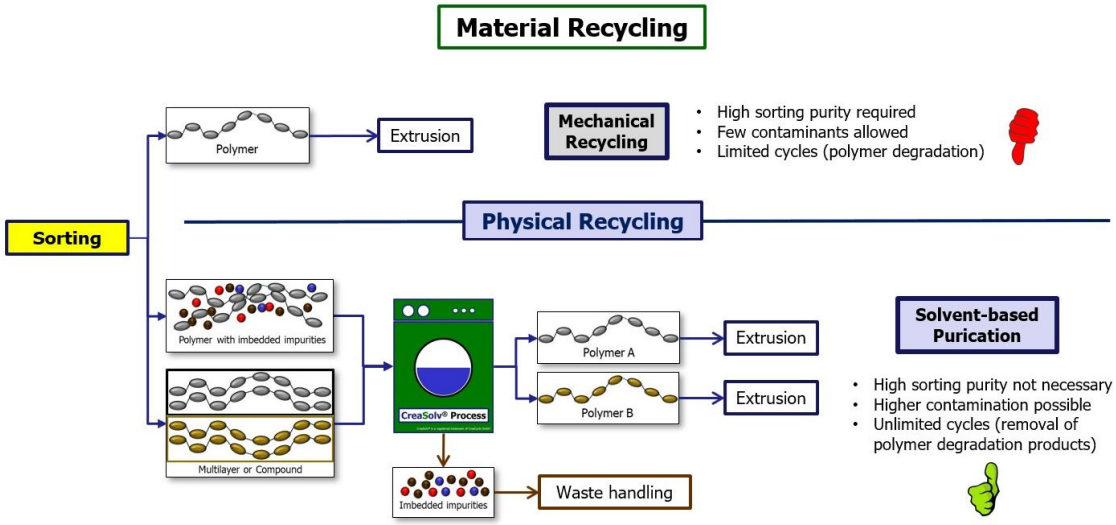
It is probably difficult to deny that dissolution and precipitation are physical changes and so we leave this subject for individual follow-up of interested readers and focus on the decrease of the average polymer chain length.

The process temperatures during a solvent-based purification are below the melting temperature of the polymer and limited by the boiling point of a solvent or a solvent preparation. Energy is costly and so the process will aim for lowest temperature possible. Interestingly cracked polymer chains from the original polymer production and extrusion are washed out as well during the purification as our cooperation partner Fraunhofer IVV could demonstrate during our 1. CreaSolv® Process project on EPS (expanded polystyrene) already in 2001 - https://www.creacycle.de/en/projects/recycling-of-expanded-poly-styrene-eps/eps-recycling-2001.html.

The degradation issue (and the accumulation) is a typical deficiency of mechanical recycling. When a virgin polymer is produced and casted or formed to an article typically in an extruder the thermal stress in the extruder causes some polymer degradation.
When this article becomes plastic waste and is mechanically recycled (re-extruded), the polymer is extruded a 2nd time and the thermal stress produces more degraded polymer chains which accumulate in the polymer with each additional recycling cycle until the physical properties decline.

Physical Recycling

Mechanical Recycling vs. Solvent-based Purification



In contrary Solvent-based Purification does not suffer from this accumulation and allows "endless" or perpetual recycling of a polymer because the degradation products can be removed during the purification. This is like a washing machine on a molecular level. Before a solvent-based purified polymer goes into an extruder, the imbedded degradation products have been washed out (like other impurities) and it is like a virgin polymer seeing its first thermal degradation stress. One could call this "upcycling".

It should be noticed that Zero Waste Europe clearly points out in their study "*that some stakeholders claim that solvent-based purification is equivalent to mechanical recycling and should not be classified as chemical recycling*" and that there is a need for clear definitions.

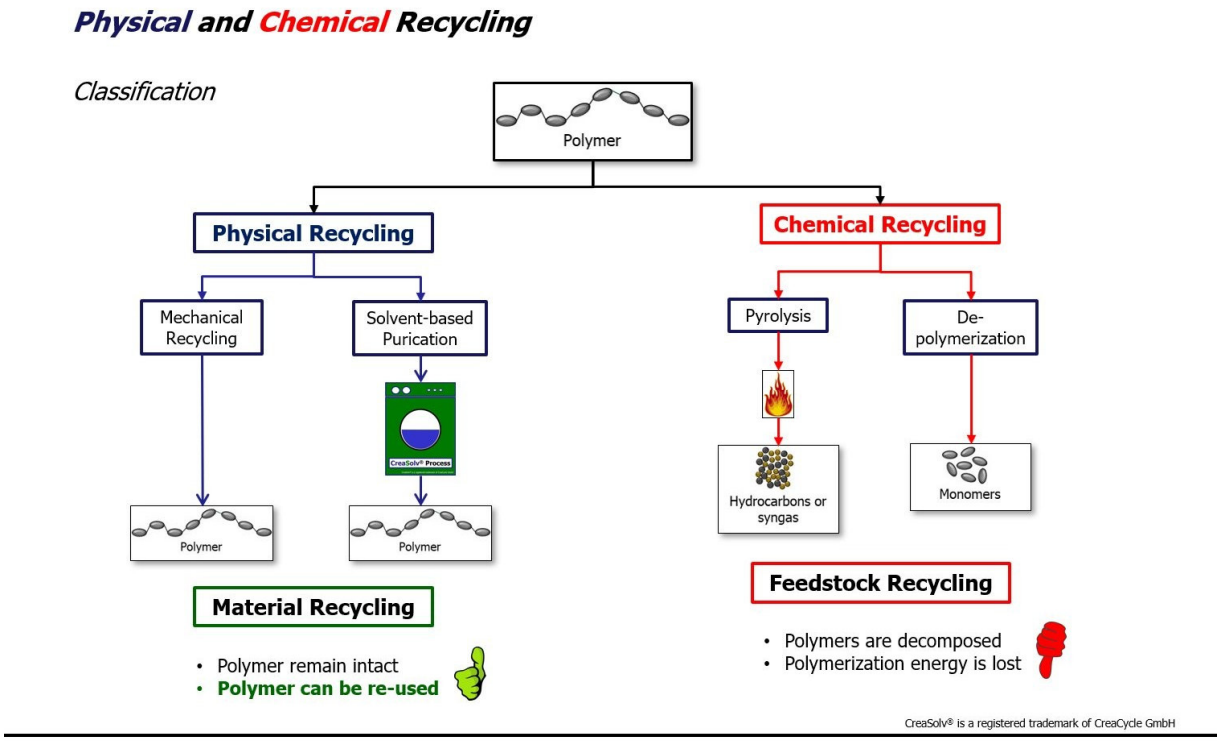
Greenpeace – Multiplier Function

In October 2019, also the Greenpeace "False Solutions Report: Throwing away the future"[2)] was launched. They base their conclusions and consultancy also on the Zero Waste Europe study and conclude "*FMCGs are anxious to label their products as both recycled and recyclable, the plastics industry and lobby is promoting the perception that full recycling will someday be possible, and companies are turning to potentially risky emerging technologies - collectively known as* ***chemical recycling***." (see pages 19-20). Solvent-based purification is classified as one of these emerging chemical recycling technologies, "*which convert plastic waste into basic chemical building blocks (polymers or monomers), including:*

- *using chemical solvents to purify waste plastics,*
- *chemical depolymerisation, in which the plastic polymer chains are degraded into their original building blocks, such as monomers, and*

- *thermal depolymerisation and cracking (breaking the chemical bonds, as used in petroleum refining) also known as gasification and pyrolysis, which can produce hydrocarbons such as gas or oil (plastic to fuel) as well as 'like-new' plastic materials."*

Chemical solvents and depolymerisation decontaminate the plastic, but the plastic that results from the process is still of degraded quality.



When Greenpeace describes polymers and monomers as "building blocks", according to Wikipedia "***Building Block***[3)] is a term in chemistry which is used to describe a virtual molecular fragment or a real chemical compound the molecules of which possess reactive functional groups". A chemist would see *Building blocks* as basic components for organic synthesis.

A polymer is definitely not a Building Block. It is the end-product of a chemical polymerization reaction of monomers, which are the building blocks.
By mixing up chemical terms and incorrectly describing Solvent-based Purification and its end-products Greenpeace creates confusion and misinformation and (maybe unknowingly) comes to a wrong conclusion as base for their consultancy and recommendation.

Conclusion

Plastic Recycling is a difficult subject. It is understandable if someone is critical and demands effective high-quality plastic recycling technologies which keep the polymers intact to allow re-use in original applications (besides reducing the amount of plastic used, or changing packaging design, etc.), but it is really sad, frustrating and not helpful, if those pushing for improvement (what is a good thing) don't get the sciences right and discredit technologies like Solvent-based Purification, which can function as a real alternative to chemical recycling, because it keeps the polymer intact for reuse in a functioning Circular Economy. Re-use is

preferred in the Waste Hierarchy and so it is only logical to assume that the same principle can be applied when comparing recycled clean polymers with chemically recovered (down-cycled) building blocks. And then we have not compared the CO_2 footprints at all, which would also be in favor for Physical Recycling.
Herewith we would like to invite Greenpeace and other environmental groups to contact us and our cooperation partner Fraunhofer Institute for Process Engineering and Packaging IVV in order to learn about the CreaSolv® Process and how this technology really works.
Similar to Zero Waste Europe we are also interested in clear definitions to differentiate between plastic waste recycling technologies so that it is possible to compare strengths and weaknesses and enable meaningful decisions on future directions. ***Plastic waste is too valuable to end up as single-use fuel or energy***.

CreaSolv® is a registered trademark of CreaCycle GmbH

Literature

1. Zero Waste Europe "Eldorado of Chemical Recycling" published October 2019: https://www.chemicalrecycling.eu/knowledge-base/zero-waste-europe-eldorado-of-chemical-recycling-state-of-play-and-policy-challenges/
2. Greenpeace "False Solutions Report: Throwing away the future", published October 2019 : https://www.greenpeace.org/usa/wp-content/uploads/2019/09/report-throwing-away-the-future-false-solutions-plastic-pollution-2019.pdf
3. Wikipedia – Building Block – https://en.wikipedia.org/wiki/Building_block_(chemistry)

In order to protect resources and our environment, high-quality recycling technologies for plastic waste are required, which allow the reuse of polymers without breaking up the polymer chains.
CreaCycle GmbH and the Fraunhofer Institute for Process Engineering and Packaging (IVV) in Freising, Germany combined their competencies in a cooperation aimed at "Plastic/Raw-Material Recycling with a Solvent-based Purification Technology" (selective extraction) and developed the CreaSolv® Process that is based on physical changes and leaves the polymer composition intact.
Proprietary CreaSolv® Formulations from CreaCycle with the lowest risk potential possible for user and environment dissolve selectively a target polymer. This reduces besides the hazard also the cost for the equipment. After the separation of imbedded impurities or undesired polymers the recycled polymer can be reused in its original application.

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