Removal of legacy substances and recycle of recycled polyvinyl-chloride (PVC) via sustainable extrusion processes

Plastics Circularity Multiplier

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More information on REMADYL: http://www.remadyl.eu/

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- PVC and PVC recycling
- Legacy substances
- REMADYL – removal of legacy additives

Polyvinyl chloride - PVC

- World's third-most widely produced synthetic plastic polymer (after polyethylene and polypropylene)
- Versatile, extremely durable, easy to clean, fire resistant and has an excellent ratio of economic cost to performance
- About 40 million tons of PVC are produced each year
- Two basic forms
  - Rigid PVC applications: construction (pipe and profile), bottles, non-food packaging, food-covering sheets, and cards (such as bank or membership cards), phonograph records
  - Soft PVC applications: electrical cable insulation, imitation leather, flooring, signage, inflatable products, and many applications where it replaces rubber






PVC Recycling

- **Landfill** – loss of a valuable material resource → not acceptable
  - Many countries have already banned landfilling of untreated organic wastes
  - **Additives in PVC plastic create further landfill problems → potential for leaching into the soil and air**

- **Incineration with energy recovery** – PVC has a heat value of approximately 19 MJ/kg → useful contribution as fuel for power generation through waste incineration
  - PVC releases the gas form of **highly corrosive HCl** → incineration regulations state that this and other **resultant toxins must be contained and neutralized**
  - Ash from PVC incineration also contains **hazardous substances (Cd and Pb) → ash must be sent to controlled landfills**

PVC Recycling

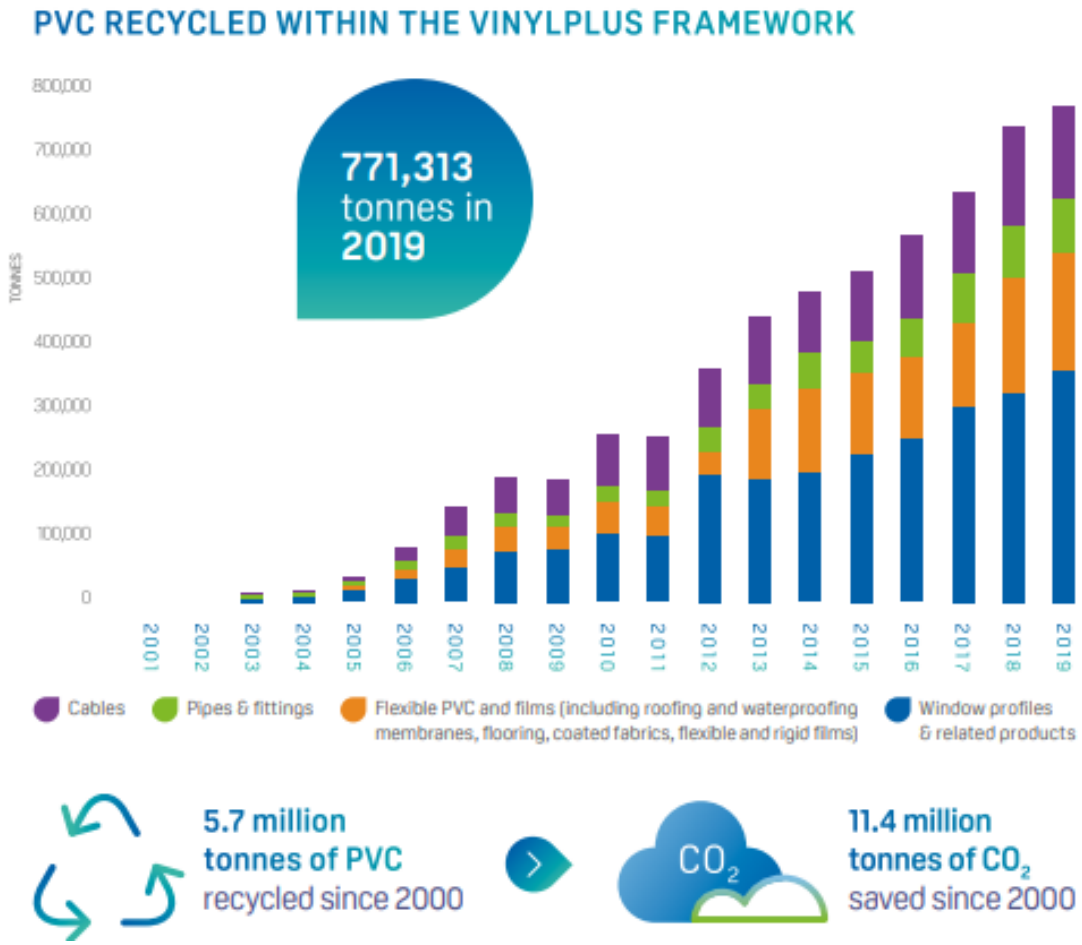
- **Chemical recycling (feedstock recycling)**
  - Break down plastics at a molecular level → requires elaborate, dedicated facilities and is more costly than mechanical recycling
  - Less preferred for general PVC waste, but it stands as an option for many materials that are too impure or contaminated for mechanical recycling

- **Mechanical recycling** – used in PVC production and processing for many decades
  - Largest proportion of unmixed PVC waste flows directly back into production
  - Number of initiatives for the recovery of post-consumer waste
  - Mechanical recycling can take place up to ten times as it does not result in a shortening of the molecule chains
  - **This process does not remove any hazardous substances from PVC, but adding new material can dilute the existing toxicity**

PVC recycling

- PVC is well suited to recycling: it has the longest history of recycling of all plastics
- PVC has advanced mechanical recycling systems
- Large volumes of recyclable PVC waste are available
- Using recycled PVC helps meet resource efficiency objectives and allows for the preservation of raw materials
- Due to its thermoplastic nature, PVC can be recycled several times without significant loss of performance

PVC Recycling



5.7 million tonnes of PVC recycled since 2000

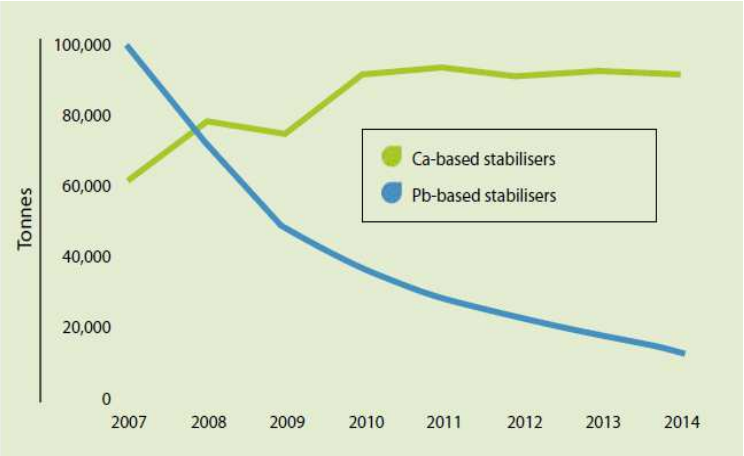
11.4 million tonnes of CO_2 saved since 2000

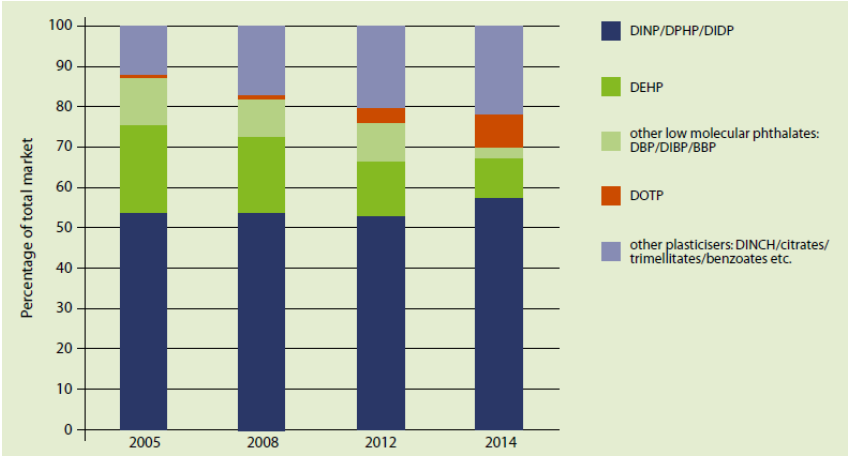
European
PVC industry has strived to increase the recycling of PVC

10-year Voluntary Commitment to sustainable development by the European PVC industry

Legacy substances

- Legacy additives: legitimately used when the products were put on the market, but now restricted
- Still found in recycled PVC from long lasting applications
- REACH → provide an extended safety data sheet for any substance or preparation containing a substance of very high concern (SVHC) → **recyclers need to know if their recyclate contains any SVHCs at a level above 0.1 % w/w**





Legacy substances

- **Plasticisers**
  - Low molecular weight phthalates
  - DEHP, DBP, diisobutyl phthalate (DIBP) and benzyl butyl phthalate (BBP)
  - Use of these phthalates in Europe is limited to certain specialised applications

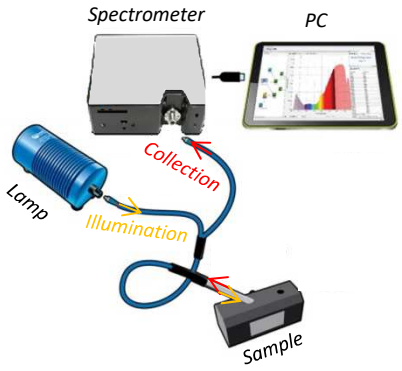
- **Stabilisers and pigments (heavy metal-based additives (lead and cadmium))**
  - Lead stabilisers were phased out across EU27 by 2015 but the long service life of many PVC products mean they will be present in the waste stream for decades
  - February 2020: European Parliament vote against a derogation that would have allowed PVC articles to be put on the market containing controlled levels of 'legacy additives', most notably lead-based stabilisers

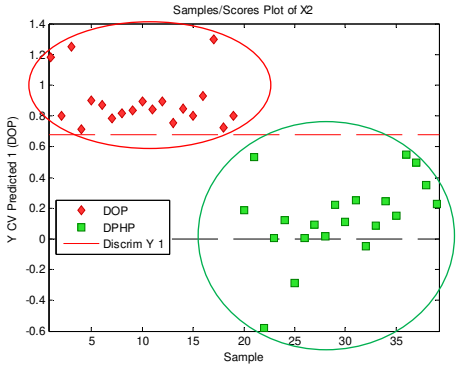
Remadyl

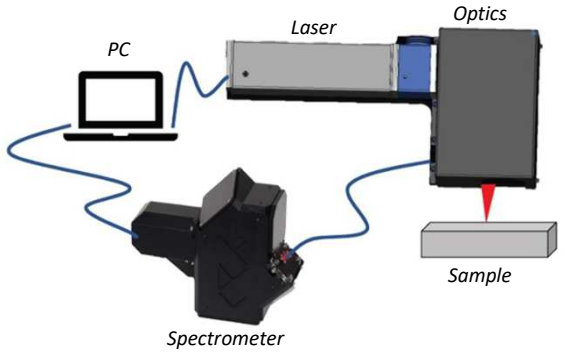
- Innovative and advanced photonic technologies for phthalate plasticiser type discrimination and lead stabiliser detection in PVC products

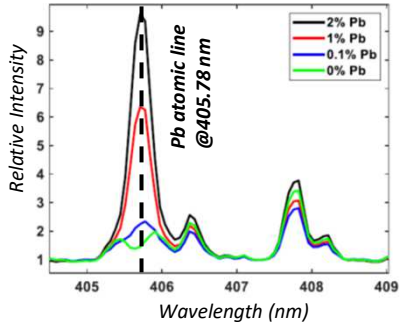
- Near IR reflectance spectroscopy
  - Preliminary results on DOP and DPHP

- Laser based spectroscopy (LIBS)
  - Preliminary results on lead content detection capability





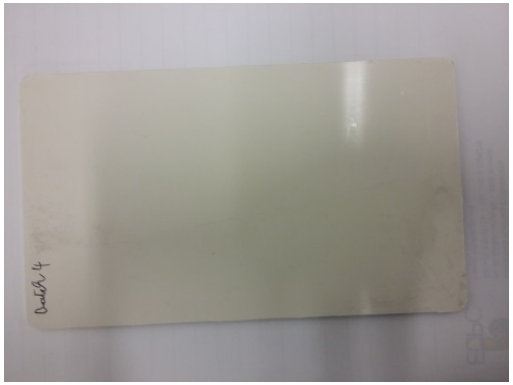




- First promising plasticizer batch extraction test were performed on PVC dryblends and PVC sheets (mostly containing mainly DEHP)

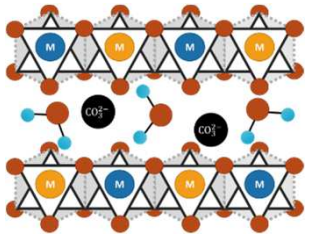
- The extraction achieved good yields > 70 %
- Development of a continuous extraction process

- Use of innovative co-solvents for the removal of legacy additives
- First promising stabilizer batch extraction test were performed on PVC granulate



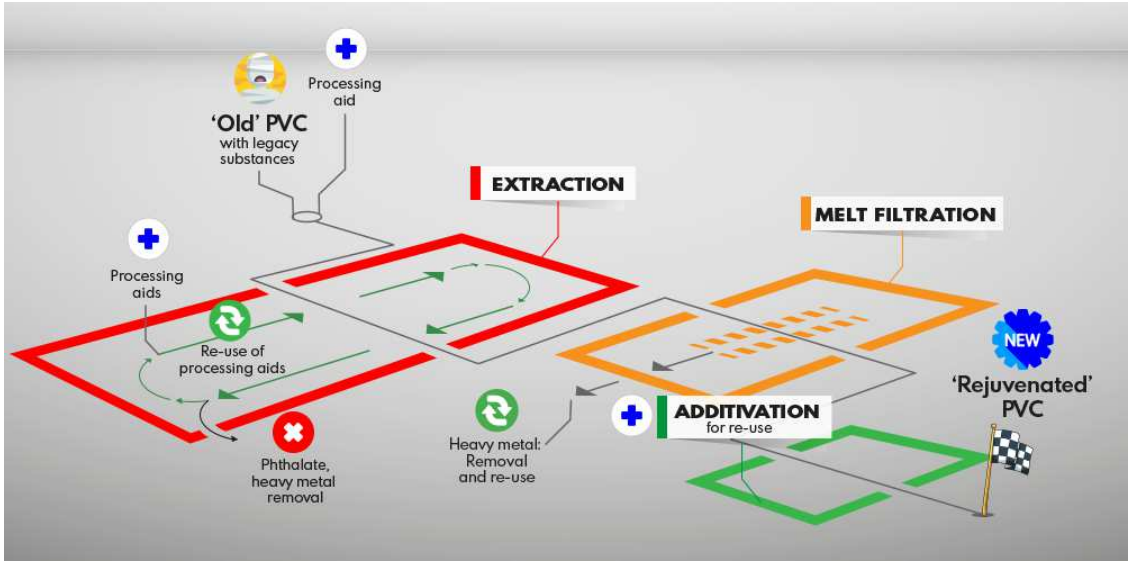
- Pb concentration: 2 w% → extraction achieved good yields > 80 %
- Development of a continuous extraction process

- Development of MoS4-SDH based process for lead removal
  - Semi-pilot synthesis to obtain the LDH precursor material at a larger scale



  - Evaluation of efficiency of MoS4-LDH as lead adsorbent: filter mineral fillers from PVC, including preblended LDH

- PVC recycling and compliancy to the European legislation



- Collaboration

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