Characterization of polypropylene waste and its potential valorisation

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Introduction

The amount of plastic waste is increasing daily due to its production from petrochemical oil sources and its non-biodegradable nature, taking hundreds of years to decompose. Polypropylene (PP) is one of the most commonly used petrochemical polymers in scientific, industrial, and household products, resulting in significant waste after its useful life. In Europe, PP waste (PPW) are typically recycled using mechanical or pyrolysis methods with purpose to reduce the consumption of raw materials such as oil and propylene, lower energy requirements for manufacturing new products, reintroduce raw materials into the economic cycle, and decrease the amount of plastic waste in landfills or incinerators. However, the fragmentation of PPW into micro and nanoplastics has created environmental and potential health risks. The process of recycling PPW generally involves consecutive phases such as collection, selection, shredding, cleaning, regranulation and valorization (Figure 1).

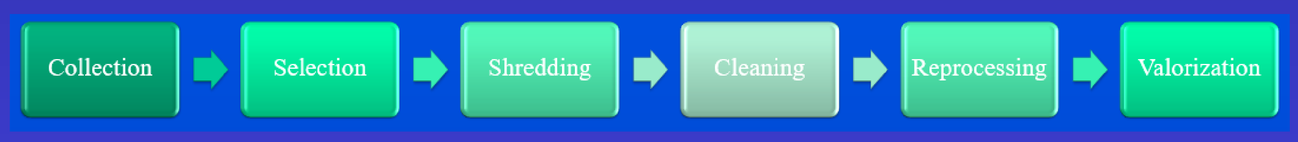


Figure 1: Scheme of mechanical recycling steps for PP wastes

The aim of this paper is to characterize six types of post-consumer PPW obtained from auto pieces (PPW1), textile cones (PPW2), cloths (PPW3), bags (PPW4), boxes (PPW5) and casseroles (PPW6) (Figure 2). These waste were processed by a laboratory roller type W 110 E COLLIN and a laboratory press type P 200P COLLIN 164 in order to obtain sheets (Figure 3).

The characterization of PPW was performed to determine the main physical, mechanical and thermal parameters such as: melt flow index, density, tensile properties, hardness Shore, Izod impact, VICAT softening temperature, heat deflection temperature, melting temperature, degree of crystallinity, and thermal stability.

Results & Discussion

Table 1. Technological parameters for obtaining of PPW sheets.

Parameters	U.M.	Value
Rolling		
Rolling temperature	°C	165 – 170
Rolling time	minute	10
Friction ratio		1/1.2
Pressing		
Preheating time	minute	4
Pressing time	minute	2
Pressing temperature	°C	175
Pressure	atm.	164
Cooling time	minute	45

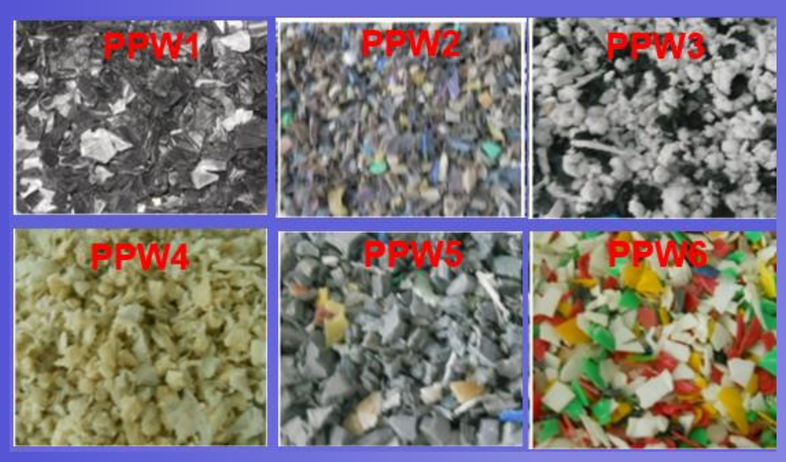


Figura 2: Post-consumer PP waste.

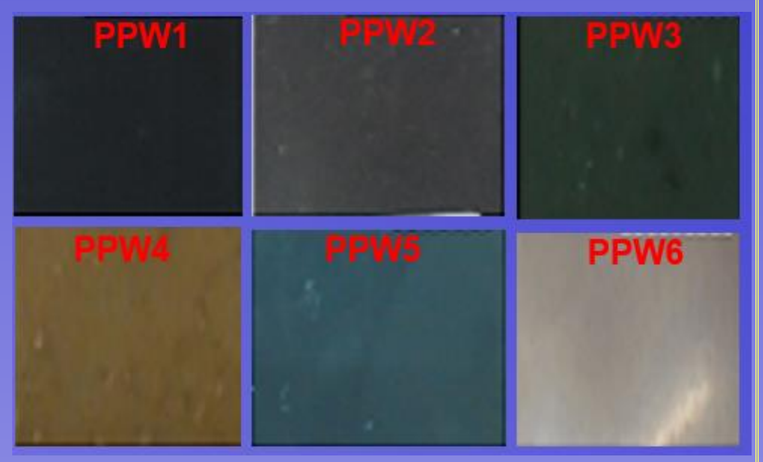
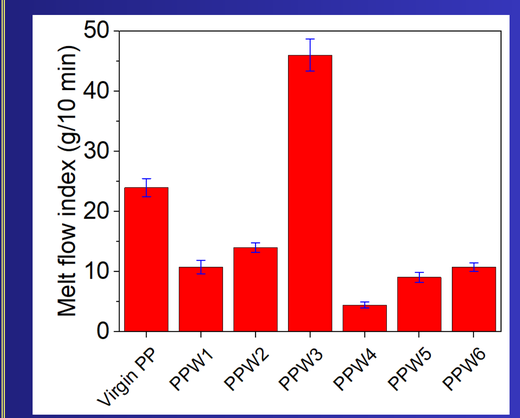
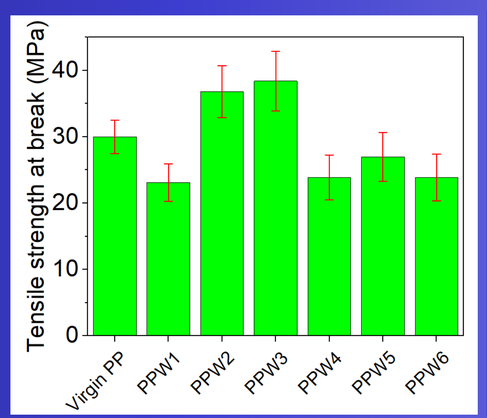
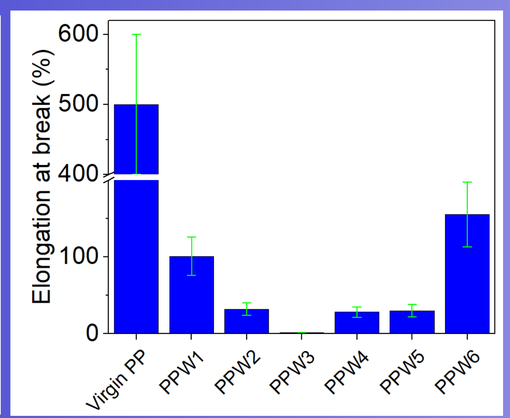
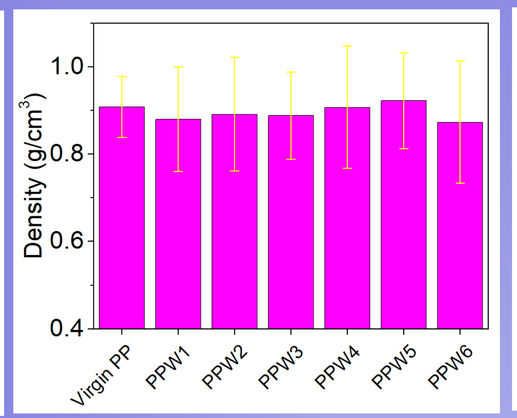


Figura 3: PPW sheets with dimension of (150x150x4) mm.









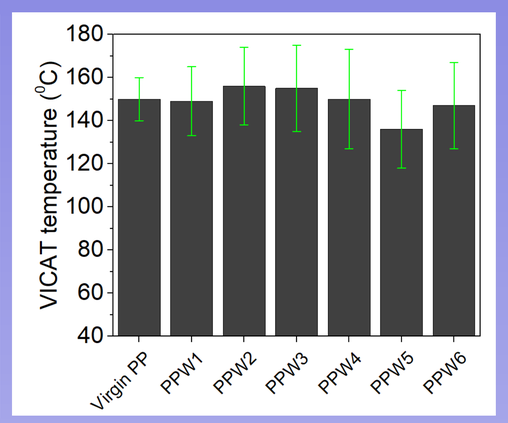


Table 2. DSC parameters for the PPW.

Sample	ΔHm, J/g	Tm, ◦C	Xc, %	Toxidation, ◦C
Virgin PP	108.9	165.5	57.0	219.7
PPW1	104.3	146.1	54.0	231.1
PPW2	106.4	164.6	54.9	214.6
PPW3	53.9	165.5	28.1	223.8
PPW3	97.0	163.5	55.4	221.8
PPW4	100.4	164.5	52.1	218.1
PPW5	94.6	130.3; 163.5	51.9	210.7
PPW6	93.1	129.5; 167.0	56.0	221.4

Based on the obtained results, PPW from boxes was selected for modification with 10 wt% elastomer to create products for specific applications using injection molding and extrusion technologies.

Conclusions

The analyzed samples exhibit some similar physico-mechanical and thermal values, while other properties differ. Typically, the tensile strength of PPW decreases compared to PP virgin, while the elongation at break increases. The DSC data indicates that PPW1, PPW2, PPW3, and PPW4 contain only PP homopolymer, whereas PPW5 and PPW6 samples are a mixture of PP homopolymer and C2-C3 copolymer. By optimizing the technical parameters in the laboratory, wheels, cable channel for automobile, flexible tube, and sealing gaskets were successfully produced by modifying PPW5 with elastomer. The data acquired emphasizes the importance of exploring various technological approaches and appropriate processing additives to utilize PPW in various environmentally beneficial applications as a valuable source of raw materials.

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