Investigation of the Physical, Mechanical and Thermal Properties of Reprocessed Nylon 6,6

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ABSTRACT

Nylon 6,6 is a widely-used engineering plastic in the automotive industry due to its excellent mechanical properties and heat resistance. However, when Nylon 6,6 undergoes recycling processes, its properties may change. This study aims to investigate the physical, mechanical, and thermal properties of Nylon 6,6 after five extrusion cycles and to evaluate its potential for reuse. The results indicate that the melt flow rate of Nylon 6,6 increases by more than 50% after two or more extrusion cycles, suggesting a decrease in molecular weight due to thermal degradation. This leads to a reduction in impact strength by more than 50%, a tensile strength reduction of up to 40%, and a 25% decrease in flexural strength after five cycles. Fourier Transform Infrared (FT-IR) analysis reveals the appearance of carbonyl (C=O) peaks in the aldehyde functional group after four extrusion cycles, indicating a thermal degradation. Differential Scanning Calorimetry (DSC) analysis shows no significant changes in thermal properties after five extrusion cycles.

In the recycling process, Nylon 6,6 that has undergone two extrusion cycles was mixed with virgin Nylon 6,6 at 10% w/w and 20% w/w ratios. The mechanical properties of both mixtures were lower than those of virgin Nylon 6,6, likely due to significant molecular structure changes in the twice-extruded material compared to material extruded once. As a result, a new formulation was developed by incorporating 5 %w/w of Nylon 6,6 extruded once. DSC analysis shows that the specific heat capacity change (ΔCp) of the new mixture closely resembles that of virgin Nylon 6,6, indicating better retention of properties.

INTRODUCTION

The automotive industry faces challenges from plastic waste generated during component production, which can negatively impact the environment. Efforts have been made to recycle this waste; however, the recycling process can alter material properties. This study examines the physical, mechanical and thermal properties of plastics after thermal processing and explores ways to enhance the properties of recycled materials for reuse in injection molding applications. The material of focus is Polyamide 66 (PA66) or Nylon 6,6 , an engineering plastic known for its toughness and high impact resistance.

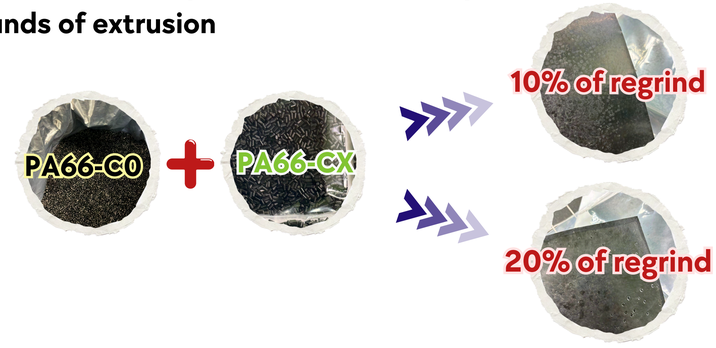
OBJECTIVES

- To investigate the physical, mechanical, and thermal properties of Nylon 6,6 after undergoing five extrusion cycles.
- To reutilize Nylon 6,6 with reduced mechanical properties by blending it with virgin Nylon 6,6.

METHODOLOGY

I: Preparation of samples for studying the properties of Nylon 6,6 after undergoing extrusion processes

II: Preparation of samples to Reutillze of Nylon 6.6 that has undergone two rounds of extrusion



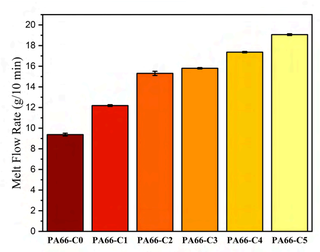
CONCLUSIONS

1. Thermal-oxidative degradation of Nylon 6,6 leads to an increase in its flow rate as the number of reprocessing cycles increases due to its molecular weight decreases. Additionally, after two reprocessing cycles, its mechanical properties deteriorate. However, its thermal properties remain unaffected. Therefore, Nylon 6,6 can be recycled once without compromising its mechanical properties.
2. When mechanically degraded recycled Nylon 6,6 is reused, it alters the properties of Nylon 6,6 blends.

RESULTS AND DISCUSSION

Properties of Nylon 6,6 after Undergoing Extrusion Processes

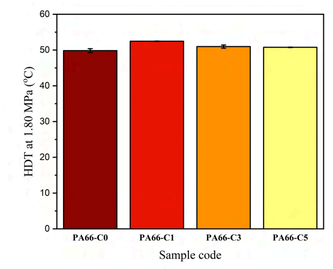
Melt Flow Rate



After five extrusion cycles, the melt flow rate of Nylon 6,6 tends to increase due to its degradation.

Fig.1 Melt flow rate of reprocessed Nylon 6,6

Thermal Testing



After five extrusion cycles, the Heat Deflection Temperature remains unchanged.

Fig.2 Heat Deflection Temperature of reprocessed Nylon 6,6

Mechanical Testing

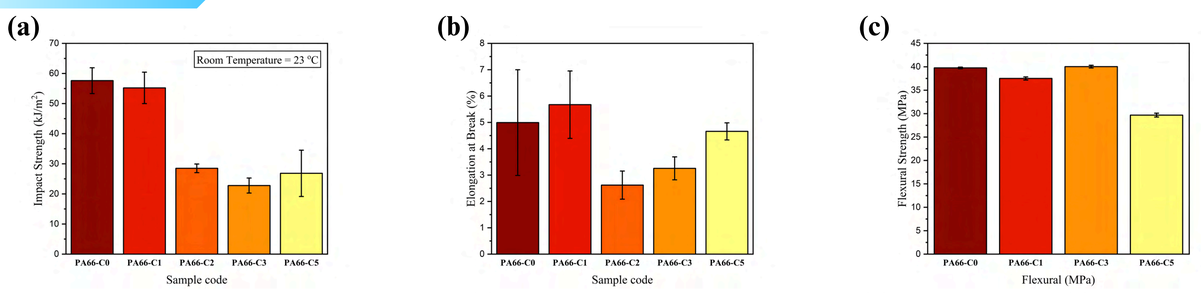
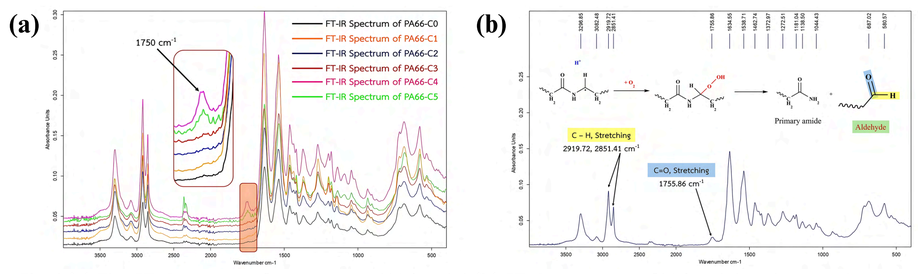


Fig.3 Mechanical properties of reprocessed Nylon 6,6; **(a)** Charpy Notched Impact Strength at 23 °C **(b)** Elongation at Break **(c)** Flexural Strength

Mechanical property testing shows that:
(a) Impact resistance decreases by 50% after two extrusion cycles. **(b)** The elongation of Nylon 6,6 decreases by 48% after two extrusion cycles. **(c)** Flexural strength decreases by 25% after five extrusion cycles.

Structural Analysis



The FT-IR spectrum indicates that Nylon 6,6 undergoes thermal-oxidative degradation, leading to a decrease in molecular weight and the formation of aldehyde by-products, as evidenced by the C=O stretching peak at 1750 cm⁻¹.

Fig.4 (a) The FT-IR spectra of reprocessed Nylon 6,6 **(b)** FT-IR spectrum of Nylon 6,6 undergoes 4 extrusion cycles

Reusing Reprocessed Nylon 6,6

Blending extruded Nylon 6,6 with unprocessed Nylon 6,6 results in a 50% and 30% reduction in impact resistance and elongation, respectively, compared to unprocessed Nylon 6,6.

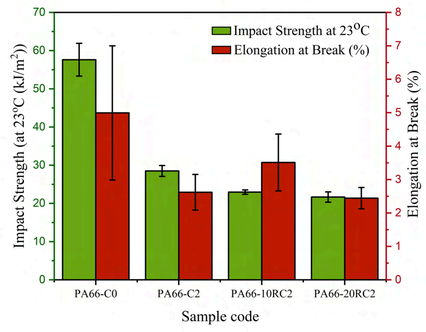


Fig.5 Mechanical properties of Nylon 6,6 blends

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