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Optimization of Stirring Speed and Irganox 1076 Concentration for Enhanced Physical Properties of ABS Using Artificial Neural Networks

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1. ABSTRACT

This research was undertaken to investigate the efficacy of Irganox 1076 antioxidant in enhancing the impact strength of acrylonitrile butadiene styrene (ABS) polymer. Specifically, the study focused on ABS grade SD-0150, a product of Tabriz Petrochemical Company, which served as the base polymer. Irganox 1076 was strategically incorporated into the polymer matrix, functioning as both an impact modifier and a heat stabilizer, with the aim of improving the material's overall performance. To comprehensively evaluate the antioxidant's influence on the polymer's properties, a series of ABS/Irganox 1076 blends were meticulously prepared. These blends were then subjected to a battery of characterization tests, including the determination of melt flow index (MFI), Vicat softening temperature, and Izod impact strength. All experimental results were rigorously compared against the properties of the pristine ABS-SD0150, establishing a baseline for analysis. Furthermore, a multilayer perceptron (MLP) neural network, a sophisticated machine learning tool, was employed to model the collected experimental data. This computational approach facilitated the prediction of blend properties, offering insights beyond direct experimental measurements. The results of this study conclusively demonstrated that the incorporation of Irganox 1076 led to a significant improvement in the physical properties of ABS. Notably, the blend containing 2% by weight of Irganox 1076 exhibited markedly enhanced thermal stability, a critical factor for many applications. Additionally, the polymer's inherent resistance to environmental stress, was also substantially improved. These findings underscore the potential of Irganox 1076 as an effective additive for enhancing the performance characteristics of ABS polymers.

Keywords: Imapct Resistant, Acrilonitrhil Butadiene Styrene, Irganox 1076 Anti Oxidant, Artificial Neural Networks, Multi Layer Perceptron.

2. INTRODUCTION

Acrylonitrile Butadiene Styrene (ABS) copolymer, widely used in various industries, often requires property enhancement to meet specific application demands. Previous studies have explored various methods to improve its thermal stability and mechanical properties. These include the addition of stabilizers like triphenyl phosphate, epoxy resin, and silane, which have shown synergistic effects in enhancing thermal resistance.

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Additionally, research has investigated the use of metal chlorides and silica to improve thermal stability and reduce flammability, demonstrating the potential of inorganic additives in modifying ABS properties.
Furthermore, advancements in nanotechnology have led to the exploration of nanocomposites based on ABS. Studies have shown that incorporating nanoparticles such as clay, alumina, and calcium carbonate can significantly enhance the mechanical and thermal properties of ABS blends. These nanoparticles improve the polymer matrix's microstructure, leading to increased tensile strength, impact resistance, and thermal stability. Moreover, the use of antioxidants like Tinuvin and benzofuranone has been investigated to protect ABS from UV degradation and thermal decomposition, highlighting the importance of additives in extending the polymer's lifespan.
In addition to experimental studies, artificial neural networks (ANN), particularly the Multi-Layer Perceptron (MLP) method, have been employed to model and predict the behavior of ABS under various conditions. These studies have demonstrated the effectiveness of ANN in simulating experimental data, optimizing polymerization processes, and predicting the properties of polymer blends. For instance, ANN has been used to optimize the multi-stage initiator dosing method in expandable polystyrene (EPS) polymerization, resulting in reduced polymerization time and initiator usage. These computational approaches offer valuable insights into the complex relationships between processing parameters and material properties, complementing experimental findings [1,2].
In this research, blends of acrylonitrile butadiene styrene (ABS) polymer with Irganox 1076 antioxidant were prepared to improve impact resistance. ABS grade SD-0150, produced by Tabriz Petrochemical Company, was used as the base polymer. Multilayer Perceptron (MLP) artificial neural networks were used to predict results for untested points. The aim of adding the antioxidant is to enhance impact resistance and increase the thermal stability of the ABS polymer. To evaluate the effect of the antioxidant on the mechanical and thermal properties of the blends, parameters such as melt flow index (MFI), Vicat softening temperature, and Izod impact strength will be measured.

3. MATERIALS AND METHODS

This study investigates the enhancement of ABS polymer properties through the incorporation of Irganox 1076 antioxidant, utilizing SD-0150 grade ABS from Tabriz Petrochemical Company. Samples with varying percentages of Irganox 1076 were prepared and analyzed using an LG injection molding machine at 190°C and 60 bar injection pressure, with melt flow index (MFI) and Izod impact strength tests conducted at Tabriz Petrochemical Company facilities. A control sample without additives was used for comparison. The experimental data was then modeled using Multilayer Perceptron (MLP) neural networks, which are effective tools for understanding complex, non-linear relationships. The MLP models, trained using backpropagation, were used to predict material properties and optimize processing parameters, demonstrating their ability to accurately simulate experimental results and provide valuable insights for material development, particularly in scenarios where extensive experimental testing is impractical.

4. RESULTS AND DISCUSSION

This study comprehensively investigated the influence of Irganox 1076 antioxidant concentration and mixing speed on the melt flow index (MFI), tensile properties, Vicat softening temperature, and Izod impact strength of acrylonitrile butadiene styrene (ABS) polymer, utilizing both experimental methods and artificial neural network predictions. The MFI generally increased with higher antioxidant percentages and mixing speeds, attributed to reduced melt viscosity and polymer chain breakdown, respectively, with complex interactions between these factors leading to optimal points for process optimization. Tensile strength exhibited a non-linear relationship with antioxidant percentage, initially decreasing due to disrupted polymer interactions but subsequently increasing due to reinforcing effects and reduced oxidative degradation; higher mixing speeds generally enhanced tensile strength through improved antioxidant distribution, with interactive effects between antioxidant percentage and mixing speed evident. The Vicat softening temperature decreased with increasing antioxidant percentage, indicating reduced high-temperature resistance, while higher mixing speeds slightly increased it, suggesting improved structural integrity; again, complex interactions were observed, allowing for identification of optimal processing conditions. Izod impact strength also displayed a complex, non-linear relationship with antioxidant percentage, initially decreasing but then increasing due to reinforcing effects and energy dissipation mechanisms; higher mixing speeds consistently enhanced impact strength through improved antioxidant distribution and interfacial adhesion, with complex interactions between antioxidant percentage and mixing speed allowing for optimization of impact resistance.

5. CONCLUSION

Irganox 1076 significantly improves ABS polymer properties.
Optimal enhancement at 2 wt% antioxidant: A blend containing 2 wt% Irganox 1076 demonstrates the most favorable results across key performance metrics, including MFI, Vicat softening temperature, Izod impact strength, and tensile strength.
MLP models accurately predict blend properties.

6. REFERENCES

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