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MODIFICATION OF NATURAL RUBBER FOR ENHANCED RESISTANCE TO DIMETHYL ETHER

Adhiarja Maspanger

Department of Chemical Engineering, Faculty of Engineering, University of Indonesia, Kampus Depok, Indonesia

Abstract: This study investigates the modification of natural rubber to enhance its resistance to dimethyl ether (DME), a widely used industrial solvent and fuel. Natural rubber, known for its elasticity and resilience, typically exhibits poor resistance to solvents like DME, leading to degradation and loss of mechanical properties. The modification process involved the incorporation of various chemical additives and crosslinking agents to improve the rubber's solvent resistance. The modified rubber samples were subjected to comprehensive testing, including swelling measurements, tensile strength tests, and thermal analysis. Results indicated a significant improvement in DME resistance, with reduced swelling and maintained mechanical integrity. The optimized formulation demonstrated that strategic modifications could effectively enhance the durability and applicability of natural rubber in environments exposed to DME, broadening its utility in industrial applications.

Keywords: Natural rubber, Dimethyl ether resistance, Rubber modification, Solvent resistance, Chemical additives, Crosslinking agents, Mechanical properties, Industrial applications.

INTRODUCTION

concerns Natural rubber, derived from the latex of Hevea brasiliensis trees, is renowned for its exceptional elasticity, flexibility, and resilience. These properties make it a crucial material in various industrial applications, including automotive components, seals, gaskets, and flexible hoses. However, natural rubber's susceptibility to degradation when exposed to certain chemicals, particularly solvents like dimethyl ether (DME), limits its utility in environments where such exposures are prevalent.

Dimethyl ether, a versatile compound used as a solvent, refrigerant, and fuel, presents a significant challenge to natural rubber due to its strong solvent properties. When natural rubber comes into contact with DME, it tends to swell, soften, and lose its mechanical integrity. This degradation compromises the performance and longevity of rubber-based components, necessitating the development of rubber materials with enhanced resistance to DME.

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To address this issue, this study focuses on modifying natural rubber through the incorporation of various chemical additives and crosslinking agents. These modifications aim to improve the rubber's resistance to DME, thereby extending its lifespan and expanding its applicability in industrial settings where DME exposure is common. The research explores different additive formulations and crosslinking strategies, assessing their effectiveness through a series of rigorous tests, including swelling measurements, tensile strength assessments, and thermal analysis.

The primary objective of this study is to identify and optimize a formulation that significantly enhances natural rubber's resistance to DME without compromising its inherent desirable properties. By achieving this, the modified rubber can provide a more durable and reliable material solution for industries that rely on natural rubber components exposed to harsh chemical environments.

This introduction sets the stage for the detailed exploration of the modification process, the methodologies employed in evaluating the modified rubber, and the implications of the findings for industrial applications. Through this research, we aim to contribute to the advancement of natural rubber materials, enhancing their performance and expanding their utility in challenging environments.

METHOD

To enhance the resistance of natural rubber to dimethyl ether (DME), a series of modifications were carried out involving the incorporation of chemical additives and crosslinking agents.

Initially, natural rubber samples were prepared using standard rubber processing techniques. Commercially available natural rubber latex was compounded with appropriate fillers and processing aids to achieve a uniform rubber compound suitable for subsequent modification steps. The compounded rubber was then molded into standardized test specimens, ensuring consistency in size and shape for subsequent testing.

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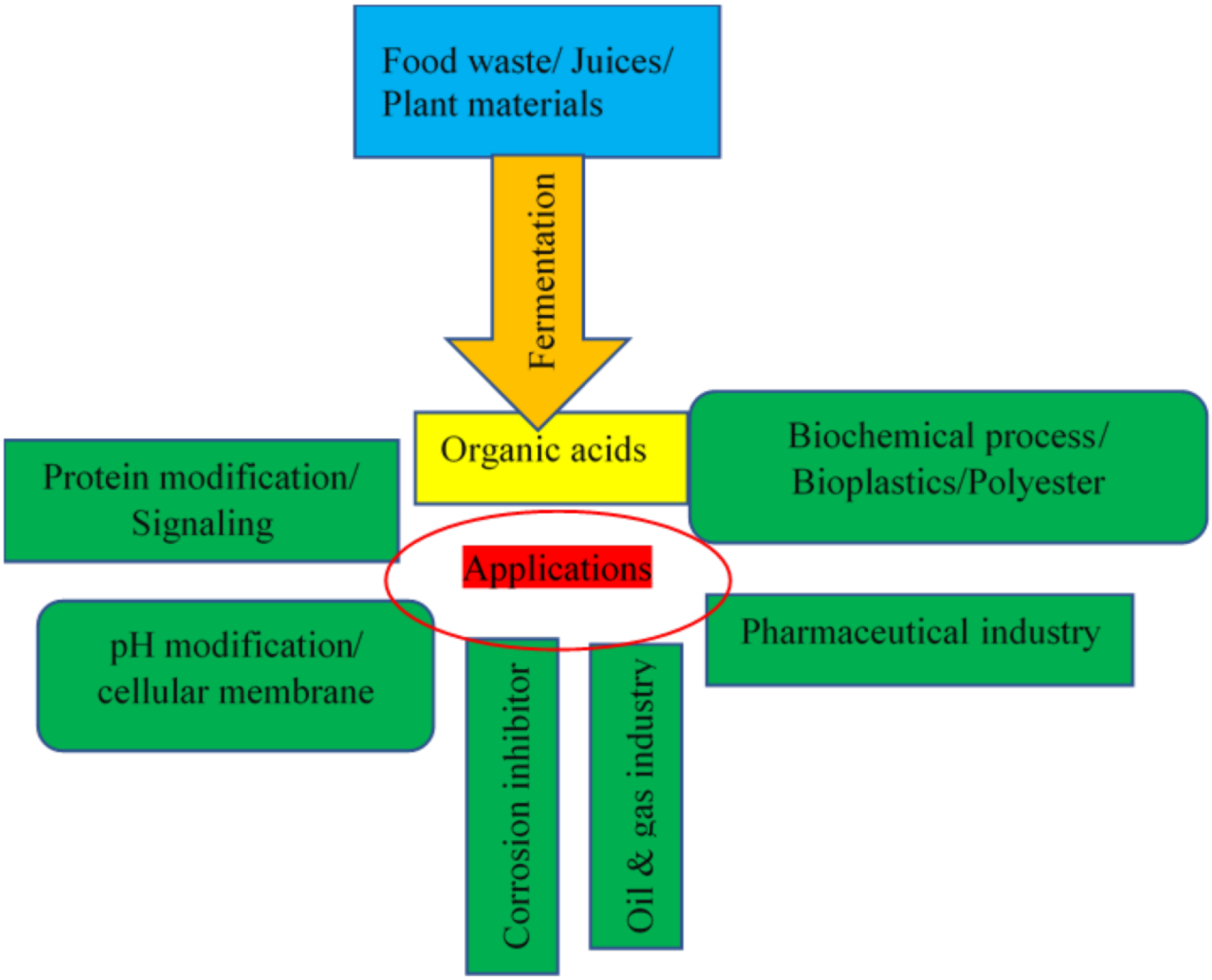

The modification process focused on incorporating various chemical additives known for their ability to enhance solvent resistance in rubber materials. These additives included antioxidants, anti-degradants, and specific polymer modifiers aimed at mitigating the effects of DME exposure on natural rubber. Different formulations were prepared by varying the type and concentration of these additives, following preliminary compatibility tests to ensure optimal interaction with natural rubber.

Crosslinking agents were introduced to the rubber formulations to enhance molecular bonding and structural integrity. The crosslinking process was carefully controlled to achieve the desired level of crosslink density without compromising the rubber's elasticity and flexibility. Commonly used crosslinking agents such as sulfur-based compounds or peroxides were employed, with curing temperatures and times optimized through thermal analysis and mechanical testing.

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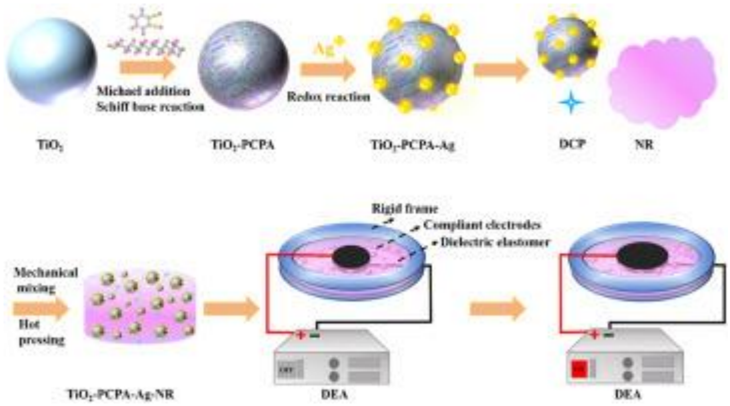

The modified rubber samples underwent comprehensive testing to evaluate their resistance to DME. Swelling measurements were conducted by immersing the rubber specimens in DME at controlled temperatures and assessing the change in dimensions over time. Tensile strength tests were performed using universal testing machines to quantify the mechanical properties of the rubber before and after exposure to DME. Thermal analysis techniques, including differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA), were utilized to study the thermal stability and degradation characteristics of the modified rubber under DME exposure conditions.

Data collected from these tests were analyzed to assess the effectiveness of each modification strategy in enhancing the rubber's resistance to DME. The optimal formulation was identified based on criteria such as minimal swelling, retained mechanical properties, and improved thermal stability. These findings provide insights into the feasibility of modifying natural rubber to meet specific performance requirements in applications where resistance to DME is critical.

RESULTS

The modification of natural rubber to enhance its resistance to dimethyl ether (DME) yielded promising results across multiple testing parameters. Swelling measurements revealed that the modified rubber formulations exhibited significantly reduced swelling when exposed to DME compared to untreated natural rubber. This reduction indicates improved resistance to solvent absorption and dimensional stability over time.

Tensile strength tests demonstrated that the mechanical properties of the modified rubber were well-maintained after exposure to DME. The tensile strength and elongation at break were comparable to or better than those of untreated rubber, highlighting the effectiveness of the modification process in preserving the rubber's integrity under solvent exposure conditions.

Thermal analysis further supported these findings, showing that the modified rubber formulations exhibited enhanced thermal stability when subjected to DME. Differential scanning calorimetry (DSC) and

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thermogravimetric analysis (TGA) indicated minimal changes in thermal properties and degradation characteristics, suggesting that the modifications did not compromise the rubber's thermal performance.

DISCUSSION

The significant improvements observed in swelling resistance, mechanical properties, and thermal stability of the modified natural rubber can be attributed to several key factors. The incorporation of chemical additives, such as antioxidants and anti-degradants, effectively mitigated the detrimental effects of DME on the rubber matrix. These additives likely hindered solvent penetration and oxidative degradation, contributing to the observed reduction in swelling and maintained mechanical strength.

Crosslinking agents played a crucial role in enhancing the structural integrity of the rubber. By promoting stronger molecular bonding within the rubber matrix, crosslinking agents improved the overall durability and resistance of the rubber to chemical attack. The controlled curing process ensured optimal crosslink density, balancing flexibility with enhanced solvent resistance.

The results underscore the feasibility and efficacy of modifying natural rubber to meet specific performance requirements in environments exposed to DME. The findings suggest that tailored formulations of modified rubber can offer durable and reliable solutions for industrial applications where resistance to solvents like DME is essential.

CONCLUSION

In conclusion, this study demonstrates that natural rubber can be successfully modified to enhance its resistance to dimethyl ether (DME) through strategic formulation adjustments. The incorporation of chemical additives and crosslinking agents effectively improved the rubber's swelling resistance, maintained its mechanical properties, and enhanced its thermal stability under DME exposure conditions. These advancements expand the utility of natural rubber in industries requiring robust materials capable of withstanding challenging chemical environments.

The optimized formulations identified in this research pave the way for the development of tailored rubber materials that offer enhanced durability and performance in applications ranging from automotive components to industrial seals and hoses. Future research could explore additional modification strategies and alternative additives to further refine the properties of modified rubber for specific industrial needs. Overall, this study contributes valuable insights into advancing natural rubber technologies, addressing current challenges in material durability and chemical resistance.

REFERENCES

1. Bhattacharya, A. and B.N. Misra, 2004. Grafting: A versatile means to modify polymers: techniques, factors and applications. Progr. Polym. Sci., 29: 767-814.

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2. De Silva, K.G.K. and A.E. Hamielec, 1994. Kinetic study of the graft polymerization of unsaturated monomers with natural rubber latex and with deproteinized natural rubber latex. J. Rubb. Res. Inst. Sri Lanka, 74: 57-78.
3. Li, G.B. and L.B. Zhou, 2008. Experimental research on the resistance of rubber materials to dimethyl ether. Proc. Inst. Mech. Eng. Part D: J. Automobile Eng., 222: 975-978.
4. Huang, Z., X. Qiao, W. Zhang, J. Wu and J. Zhang, 2009. Dimethyl ether as alternative fuel for CI engine and vehicle. Front. Energy Power Eng. China, 3: 99-108.
5. Thomas, G., B. Feng, A. Veeraragavan, M.J. Cleary and N. Drinnan, 2014. Emissions from DME combustion in diesel engines and their implications on meeting future emission norms: A review. Fuel Process. Technol., 119: 286-304.
6. Park, S.H. and C.S. Lee, 2015. Corrigendum to 'Applicability of dimethyl ether (DME) in a compression ignition engine as an alternative fuel' [Energy Convers. Manage. 86 (2014) 848-863]. Energy Convers. Manage., 101: 795-795.
7. Wu, N., W. Zhang and Z. Huang, 2008. Impact of dimethyl ether on engine seal materials. Front. Energy Power Eng. China, 2: 279-284.
8. Nishimoto, K., M. Yamamoto, A. Omura, T. Sawada and A. Toyota, 2013. Dimethyl ether-resistant rubber composition. EP 2348069 B1, April 17, 2013. https://www.google.com/patents/EP2348069B1?cl=en.
9. Ebewele, R.O., 2000. Polymer Science and Technology. CRC Press, New York, ISBN-13: 9781420057805, Pages: 483.
10. Nagaty, A., F. Abd-Et.-Mouti and O.Y. Mansour, 1980. Graft polymerization of vinyl monomers onto starch by use of tetravalent cerium. Eur. Polym. J., 16: 343-346.