Synthesis and Optimization of Industrial Biodegradable PU Footwear Soles

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Synthesis and Optimization of Industrial Biodegradable

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PU Footwear Soles

1. Introduction

Polymer industry occupied a prominent position in the global economy but also it is accountable for the respective environmental consequences. Shorter life cycle synthetic polymer has begun to create non-degradable waste in landfills due to synthetic and other non-biodegradable materials used in production. As Industry 4.0 advances, its potential to contribute to sustainable economic, environmental, and social development is gaining increasing attention. The development of environment friendly material is the need of hour for the environmental sustainability which refers to the synchronized conquest of environmental, social and economic balance.

Being an important commodity, the consumption of shoes is increasing day by day and touched nearly 23 billion pairs in the year 2019 [Footwear Book]. Since the escalating consumption of footwear tends to accumulate synthetic polymers as waste disposal in our environment, it is imperative to develop footwear components with biodegradable properties (Zavodna). PU soles have been replacing predominantly PVC soles in the past decade, and the majority of the formal higher priced leather shoes use PU for soles. PU in footwear with 13.5% of usage is the third largest application of PU in India. Hence to reduce the adverse effect of the waste materials from non-renewable sources, the utilization of polymeric products from biodegradable/renewable sources such as starch, cellulose and several other biodegradable

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monomers are being explored to improvise commercially in the market and few of them are under study. Nevertheless, current studies lack biodegradable polyurethane thorough testing of mechanical and physicochemical properties, which is essential in order for industries to analyse foam-based products. Recently, Zhang from Bayer has exemplified various challenges associated with the choice of bio-based raw materials for making shoe components. In fact, the biodegradable PU should not wear out during dressed in and should support the required physical properties at that time.Often, biodegradable raw material-based industrial polyurethane leads to polyurethane which is lacked in susceptible to microorganism. In present study the biodegradable PU based footwear material with desired physicochemical properties shows prominent susceptibility towards microbial attack/growth for the first time. The present research will further open a new avenue for the polyurethane foam (from iso and polyol) industry to join the aim of global sustainable development which is the critical in the post COVID era.

2. Objectives of the Present Work

The present work focused on the preparation of injection moulded biodegradable PU soles and footwear. In this context, the suitable choice of monomer to start synthesizing of biodegradable PU and the compatibility of the blowing agent with polyol is critical in terms of availability/cost effectiveness. It is our aim to formulate

the composition of biodegradable and environmentally friendly polyurethane materials from a suitable biodegradable/renewable polyol, diisocyanate, chain extender, catalyst, additives.

3. Materials and Methods Used

Injection moulded PU shoe soles are prepared using polycaprolactone diol (PCL), diphenyl methane diisocyanate (MDI), monoethylene glycol, water and tri amine catalyst. The reaction injection moulding system is optimized for isocyanate index and other processing parameters like cream time, tack free time and pinch time

recommended for PU system. To improve the flexibility of the soles, biodegradable PU nano-composites are prepared by adding the nanofiller in the control system and further optimized for Isocyanate index in each loading of filler to maintain the recommendation for Injection Moulding System. The injection molded shoe soles based on biodegradable PU nanocomposites were characterized by X-ray diffraction study (XRD), Infrared spectroscopy (ATR-FTIR), Thermogravimetric analysis (TGA),

Differential scanning calorimetry (DSC) and Scanning Electron Microscopy (SEM). Physical properties were determined by measuring hardness, density, Bata belt flexing, Abrasion resistance, tensile strength following standard test methods.

4. Results Obtained

The physical properties of the biodegradable PCL based PU shoe soles and PU nano-composite based shoe soles are good as per the standard requirements. SEM pictures of cross-sectional view of PU foam showed spherical bubbles of size 80 to 170 µm which confirms the normal foam formation with PCL polyol with conventional isocyanate and additives with existing injection molding system. The biodegradable PU based footwear material with desired physicochemical properties shows prominent susceptibility towards microbial attack/growth for the first time. The present research will further open a new avenue for the polyurethane foam (from iso and polyol) industry to join the aim of global sustainable development which is the critical in the post COVID era.