World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:16, No:10, 2022

Study of Phase Separation Behavior in Flexible Polyurethane Foam

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Abstract : Flexible polyurethane foam (FPUF) is a low-density cellular material generally used as a cushioning material in many applications such as furniture, bedding, packaging, etc. It is commercially produced during a continuous process, where a reactive mixture of foam chemicals is poured onto a moving conveyor. FPUFs are produced by the catalytic balancing of two reactions involved, the blowing reaction (isocyanate-water) and the gelation reaction (isocyanate-polyol). The microstructure of FPUF is generally composed of soft phases (polyol phases) and rigid domains that separate into two domains of different sizes: the rigid polyurea microdomains and the macrodomains (larger aggregates). The morphological features of FPUF are strongly influenced by the phase separation morphology that plays a key role in determining the global FPUF properties. This phase-separated morphology results from a thermodynamic incompatibility between soft segments derived from aliphatic polyether and hard segments derived from the commonly used aromatic isocyanate. In order to improve the properties of FPUF against the different stresses faced by this material during its use, we report in this work a study of the phase separation phenomenon in FPUF that has been examined using SAXS WAXS and FTIR. Indeed, we have studied with these techniques the effect of water, isocyanates, and alkaline chlorides on the phase separation behavior. SAXS was used to study the morphology of the microphase separated, WAXS to examine the nature of the hard segment packing, and FTIR to investigate the hydrogen bonding characteristics of the materials studied. The prepared foams were shown to have different levels of urea phase connectivity; the increase in water content in the FPUF formulation leads to an increase in the amount of urea formed and consequently the increase of the size of urea aggregates formed. Alkali chlorides (NaCl, KCl, and LiCl) incorporated into FPUF formulations show that is the ability to prevent hydrogen bond formation and subsequently alter the rigid domains. FPUFs prepared by different isocyanate structures showed that urea aggregates are difficult to be formed in foams prepared by asymmetric diisocyanate, while are more easily formed in foams prepared by symmetric and aliphatic diisocyanate.

Keywords : flexible polyurethane foam, hard segments, phase separation, soft segments
Conference Title : ICCMA 2022 : International Conference on Cellular Materials and Applications
Conference Location : Istanbul, Türkiye
Conference Dates : October 20-21, 2022