World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:12, No:02, 2018

Systematic Study of Structure Property Relationship in Highly Crosslinked Elastomers

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Abstract : Elastomers are polymeric materials with varied backbone architectures ranging from linear to dendrimeric structures and wide varieties of monomeric repeat units. These elastomers show strongly viscous and weakly elastic when it is not cross-linked. But when crosslinked, based on the extent the properties of these elastomers can range from highly flexible to highly stiff nature. Lightly cross-linked systems are well studied and reported. Understanding the nature of highly cross-linked rubber based upon chemical structure and architecture is critical for varieties of applications. One of the critical parameters is cross-link density. In the current work, we have studied the highly cross-linked state of linear, lightly branched to star-shaped branched elastomers and determined the cross-linked density by using different models. Change in hardness, shift in Tg, change in modulus and swelling behavior were measured experimentally as a function of the extent of curing. These properties were analyzed using varied models to determine cross-link density. We used hardness measurements to examine cure time. Hardness to the extent of curing relationship is determined. It is well known that micromechanical transitions like Tg and storage modulus are related to the extent of crosslinking. The Tg of the elastomer in different crosslinked state was determined by DMA, and based on plateau modulus the crosslink density is estimated by using Nielsen’s model. Usually for lightly crosslinked systems, based on equilibrium swelling ratio in solvent the cross link density is estimated by using Flory–Rhener model. When it comes to highly crosslinked system, Flory-Rhener model is not valid because of smaller chain length. So models based on the assumption of polymer as a Non-Gaussian chain like 1) Helmis–Heinrich–Straube (HHS) model, 2) Gloria M.gusler and Yoram Cohen Model, 3) Barbara D. Barr-Howell and Nikolaos A. Peppas model is used for estimating crosslink density. In this work, correction factors are determined to the existing models and based upon it structure-property relationship of highly crosslinked elastomers was studied.

Keywords : dynamic mechanical analysis, glass transition temperature, parts per hundred grams of rubber, crosslink density, number of networks per unit volume of elastomer
Conference Title : ICMPPM 2018 : International Conference on Materials Processing and Polymeric Materials
Conference Location : Mumbai, India
Conference Dates : February 22-23, 2018