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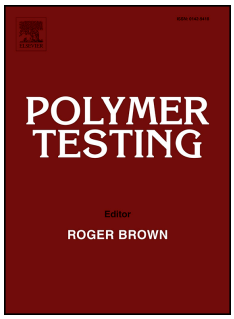

Determining strain-induced crystallization of natural rubber composites by combined thermography and stress-strain measurements

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Test Method

Determining Strain-Induced Crystallization of Natural Rubber Composites by Combined Thermography and Stress-Strain Measurements

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Abstract

Strain induced crystallization is essential to the physicochemical properties of polymer materials, but is difficult to investigate, as it usually requires X-ray sources in combination with stretching machines. We improve and validate a recently developed method which allows the calculation of the crystallinity index using easily available thermography and stress-strain data. For natural rubber, the method is shown to be reproducible and delivers results quantitatively comparable to spectroscopic methods such as wide angle X-ray scattering. The incorporation of different amounts of carbon black is shown to increase the level of crystallization and to change the shape of the strain-crystallization curves. Additionally, crystallinity during partial retraction is investigated and reveals that crystallization characteristics change at sufficiently high strain.

Keywords: Strain induced crystallization, natural rubber, filler reinforcement, thermography

Introduction

Strain-Induced-Crystallization (SIC) is a well-known phenomenon observable in many polymers. The most prominent example may be natural rubber (NR), where SIC is assumed to be responsible for its outstanding mechanical properties [13,15,14]. While NR works fine filled with carbon black, comparable silica filled compounds perform less well, especially in terms of wear. The reason for that is still under discussion and may be related to depression of SIC and/or inadequate choice of coupling agents [7].
HNBR with ACN content larger than roughly 35 % and high level of hydrogenization is able to crystallize under strain [12], while NBR is not. This indicates that HNBRs great mechanical strength is also due to SIC. Apart from that, SIC may occur in many other polymers (among them EPDM).
In contrast to crystallization in unstretched polymers, which is easy to quantify by methods such as DSC [6] or XRD, the evaluation of SIC requires much larger experimental effort. The problems start with constructing a sample holder, which allows setting precise strains or stresses, but fits the DSC machine or X-ray beam. When using X-ray, the distinction between