Factors reducing the marching modulus of silica filled tire tread compounds

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A marching modulus - a crosslinking reaction ongoing for a long period - is often observed in silica filled S-SBR/BR tire tread compounds. This phenomenon makes it difficult to evaluate the correct curing time[1], and as a consequence, the physical properties will vary.
It is already described in the literature that the curing behavior of silica filled rubber compounds is affected by the mixing conditions[2,3] and compound characteristics[4,5], which are related to silica dispersion, the silanization and the filler-polymer coupling reaction (Figure 1). This implies that these factors are the keys to reduce and finally avoid marching modulus.

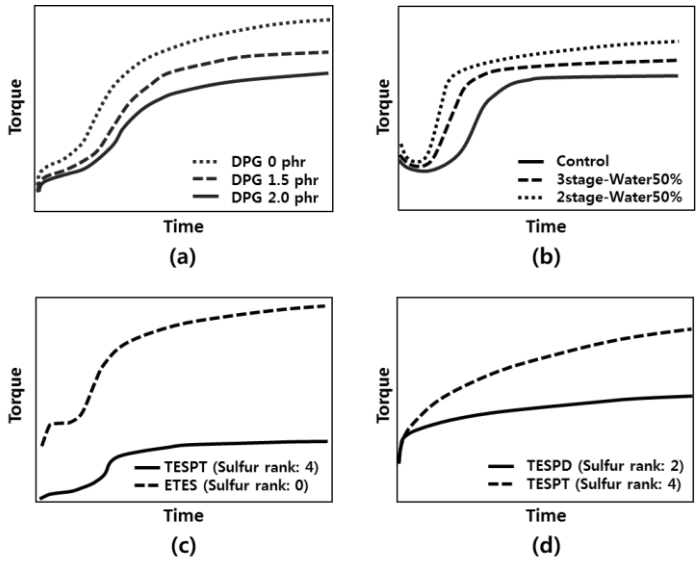

Figure 1: Influencing factors for the marching modulus: Effect of (a) DPG concentration in the non-productive mixing stage[2], (b) number of mixing stages[3], (c) and (d) sulfur rank of the silane[4,5]

In this work, the contribution of the different factors on the curing behavior of a silica filled rubber compound was studied: in a series of experiments, the correlation between different mixing conditions and compound formulations and the marching modulus intensity (MMI) was investigated. The MMI was monitored by measuring the rheogram using a Rubber Process Analyzer (RPA). All the investigated factors seem to influence the MMI, furthermore, they can all be related to the degree of dispersion and both the reactions (silanization and coupling) of the silica.

References

[1] G. Alliger, I. J. Sjothun, Vulcanization of Elastomers: Principles and Practice of Vulcanization of Commercial Rubbers, Reinhold Pub. Corp.: New York (1964)
[2] S. Mihara, PhD Thesis, University of Twente: Enschede (2009)
[3] K.-J. Kim, J. van der Kool, Rub. Chem. Tech. 78, 84 (2005)
[4] J. W. ten Brinke, PhD Thesis, University of Twente: Enschede (2002)
[5] H.-D. Luginsland, A. Hasse, 157th meeting Rub. Div. ACS Dallas, Texas, paper 34 (2000)