Experimental Analysis of Ozone Ageing in Natural Rubber

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Motivation

Cracking and brittle surfaces are associated with thermo-oxidative ageing but even faster these degradation indicators are detected for ozone-aged Natural Rubber (NR) [1]. Applications as isolators, bearings or hoses have a shortened lifetime when exposed to elevated concentrations of ozone at ground level. Due to the double bond in the main chain NR is especially prone to oxidative reactions [2].

Objectives

- Experimental analysis of the time and strain-dependent mechanism of ozone degradation in NR
- Correlating mechanical properties and chemical change to enable a material characterization of the NR after change due to the ageing process
- Preventing damage by a better understanding of the ageing process and estimation of lifetime

Selected Experimental data

Ozone loading on strained samples leads to fast surface cracking at concentrations that are measured in summer afternoons after a few hours. The crack depth can be analysed in different manners. Shown methods are via punching aged samples to analyse their cross-section under the optical microscope (OM) and via uniaxial tension tests (TT) that show the reduction in cross-section indirectly in the loss of stiffness. Fig. 1 (a) shows the results of the microscopic analysis for the maximum and minimum crack depth. Two different compounds of NR are displayed: with and without the aging protectant 6PPD[1]. In Fig. 1 (b) the methods are compared regarding the maximum crack depth of OM and the calculated one in TT.

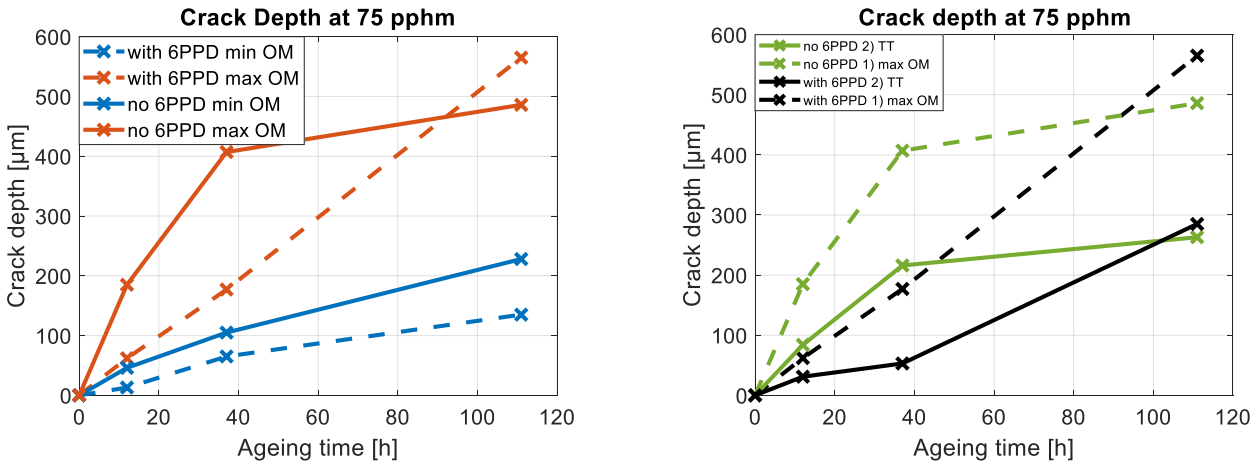

Figure 1: Crack depth of ozone-aged samples (a) minimum and maximum values measured via optical microscopy (b) calculation from tension tests in comparison to maximum values obtained in optical microscopy

The apparent correlation of the crack evolution over time at the ozone concentration of 75pphm shows the interaction of the maximum crack depth and the average loss in stiffness. Though the methods deliver different absolute values of crack depth they coincide on the beaviour with ageing time. Furthermore, a remarkable observation is the difference of crack depth in unprotected versus protected NR. The unprotected samples generate cracks faster than protected ones but seem to settle on a smaller value exceeded by the protected ones.

References

[1] Lake, G.J., 1970. Ozone cracking and protection of rubber. Rubber Chemistry and Technology 43.
[2] Cataldo, F., 2019. Protection Mechanism of Rubbers from Ozone Attack. Ozone: Science & Engineering 41, 358–368.

[1] N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine