Structure-property relationships of elastomer compounds based on “safe” process oil

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MOTIVATION:

Due to limitation on the use of process oils containing substantial amounts of polycyclic aromatic hydrocarbons (PAHs) by EC No 552/2009, all tire manufacturers had to shift to **‘safe’ process oils with lower PAHs content**. Lowering the amount of PAHs from the oil improves the rolling resistance (RR) and abrasion resistance (AR) but, negatively affects the wet skid resistance (WSR) of a tire tread.

AIM:

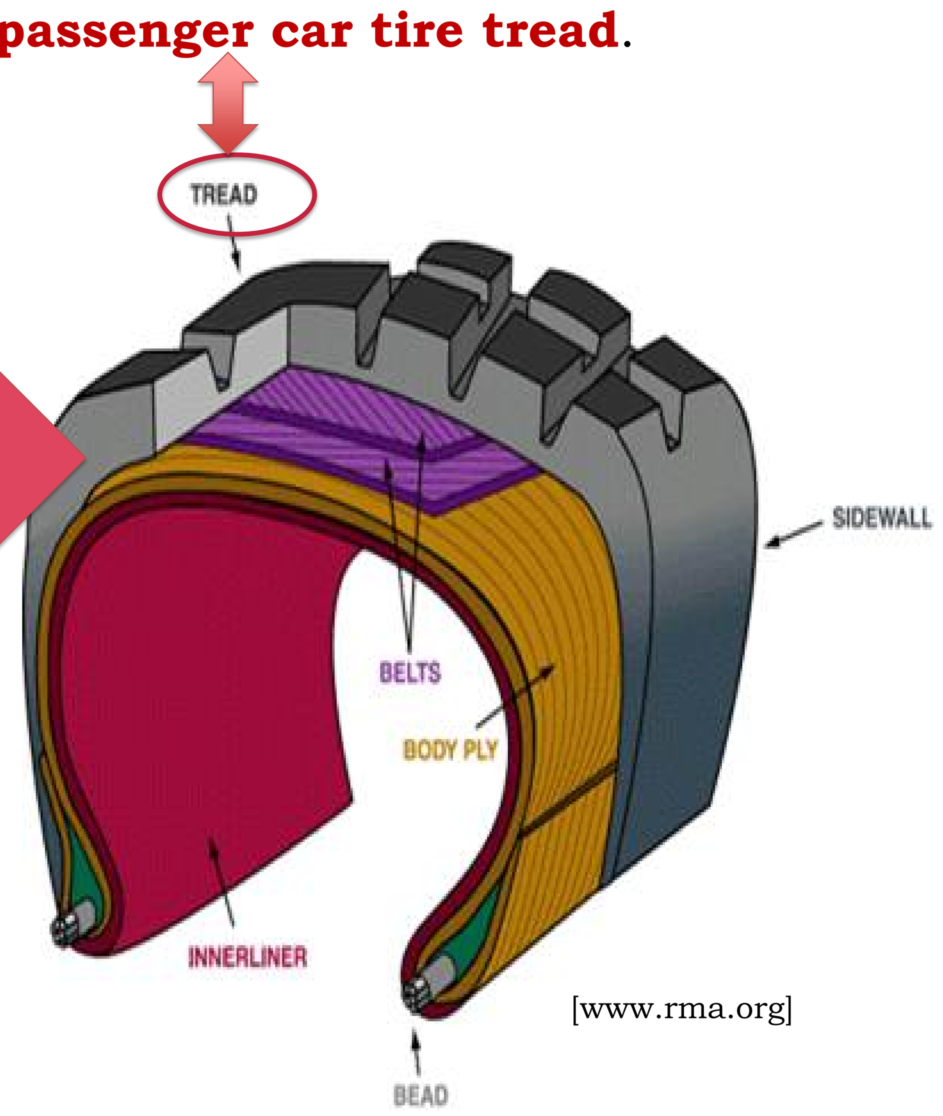
- To understand the effect of ‘safe’ process oils on properties of rubber,
- To elucidate upon the effect of ‘safe’ process oils on component relaxation dynamics in a SBR/BR (50:50 & 70:30) blend,
- To develop a ‘safe’ process oil containing rubber compound with better WSR for a **passenger car tire tread**.

INTRODUCTION:

This part of the study is focused on studying the variation in the **α-relaxation process** i.e., glass transition (T_g) dynamics of a Butadiene rubber (BR) compound by addition of different types of process oils.

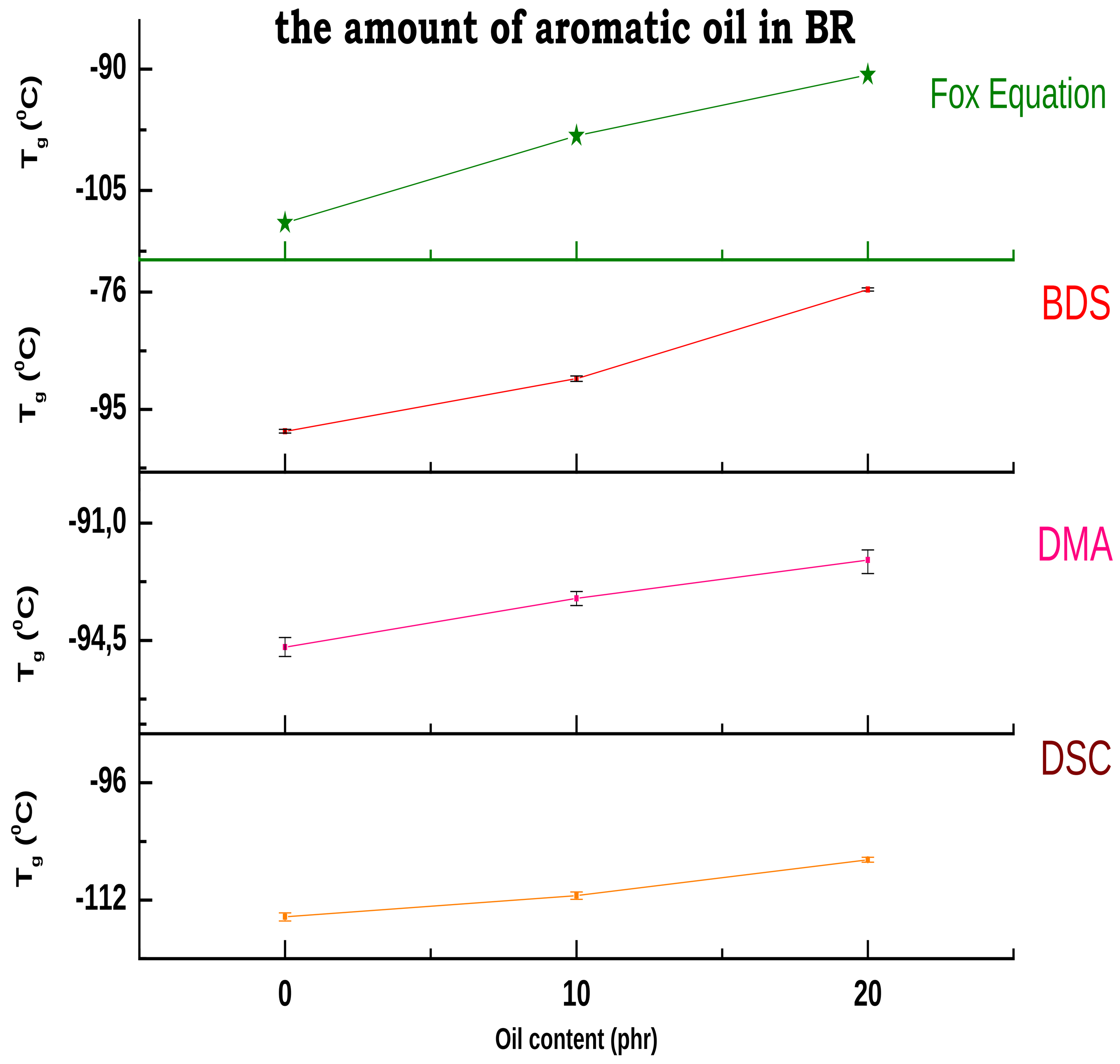
- Techniques used: Theoretical prediction (Fox Eq.), Broadband Dielectric Spectroscopy (BDS), Dynamic Mechanical Analysis (DMA) and Differential Scanning Calorimetry (DSC).

Most common elastomer blend used for a modern passenger car tire tread consists of SBR (Styrene Butadiene rubber) and BR (Butadiene Rubber) in different ratios.



RESULTS:

Comparison of T_g from different techniques on increasing the amount of aromatic oil in BR



- An advanced version of the **Fox equation**[1] is used to calculate the T_g of oil-extended rubber.

$$\frac{1}{T_g^{OE-R}} = \frac{W_{oil}}{T_g^{oil}} + \frac{W_R}{T_g^R}$$ [1]

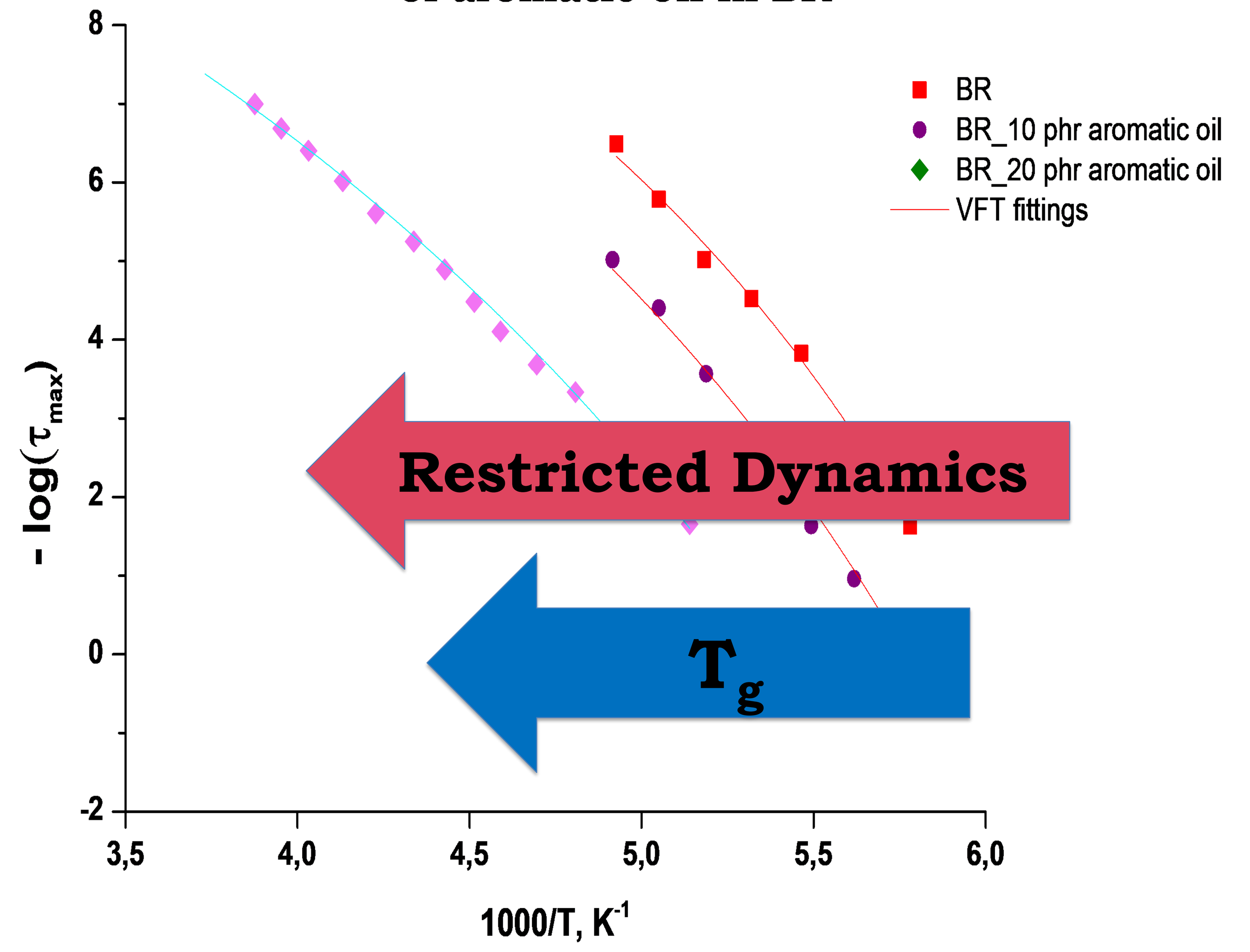
- Where, T_g^{OE-R} is T_g of oil extended-rubber; T_g^{oil} is T_g of oil; T_g^R is T_g of polymer/rubber; W_{oil} is weight fraction of oil; W_R is weight fraction of polymer/rubber.
- The observed **increase in the T_g of BR upon addition of aromatic oil** by various experimental techniques (BDS, DMA, DSC) is in accordance with the theoretical predictions based on the Fox equation for miscible mixtures.

MATERIALS:

- Vivatec 500 (Aromatic oil with Tg= -49°C)
- BR (>96% cis)[2], known to provide excellent abrasion resistance and rolling resistance in tire treads.
- **BR compounds with 0, 10 and 20 phr of the aromatic oil are studied.**

MAIN RESULT:

Shift in activation plot with increasing amount of aromatic oil in BR



NOTE: Fittings of the data points on the graph above are done using Vogel-Fülcher-Tamman (VFT)[3] equation, which governs the temperature dependency of relaxation times.

- From this activation plot, it is clear that the **motions of the highly linear polymer chains of BR are getting more restricted** with the addition of oil containing bulky aromatic groups .

REFERENCES:

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3. Doctoral thesis by M.Hernández, Universidad Complutense de Madrid, 2012.

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