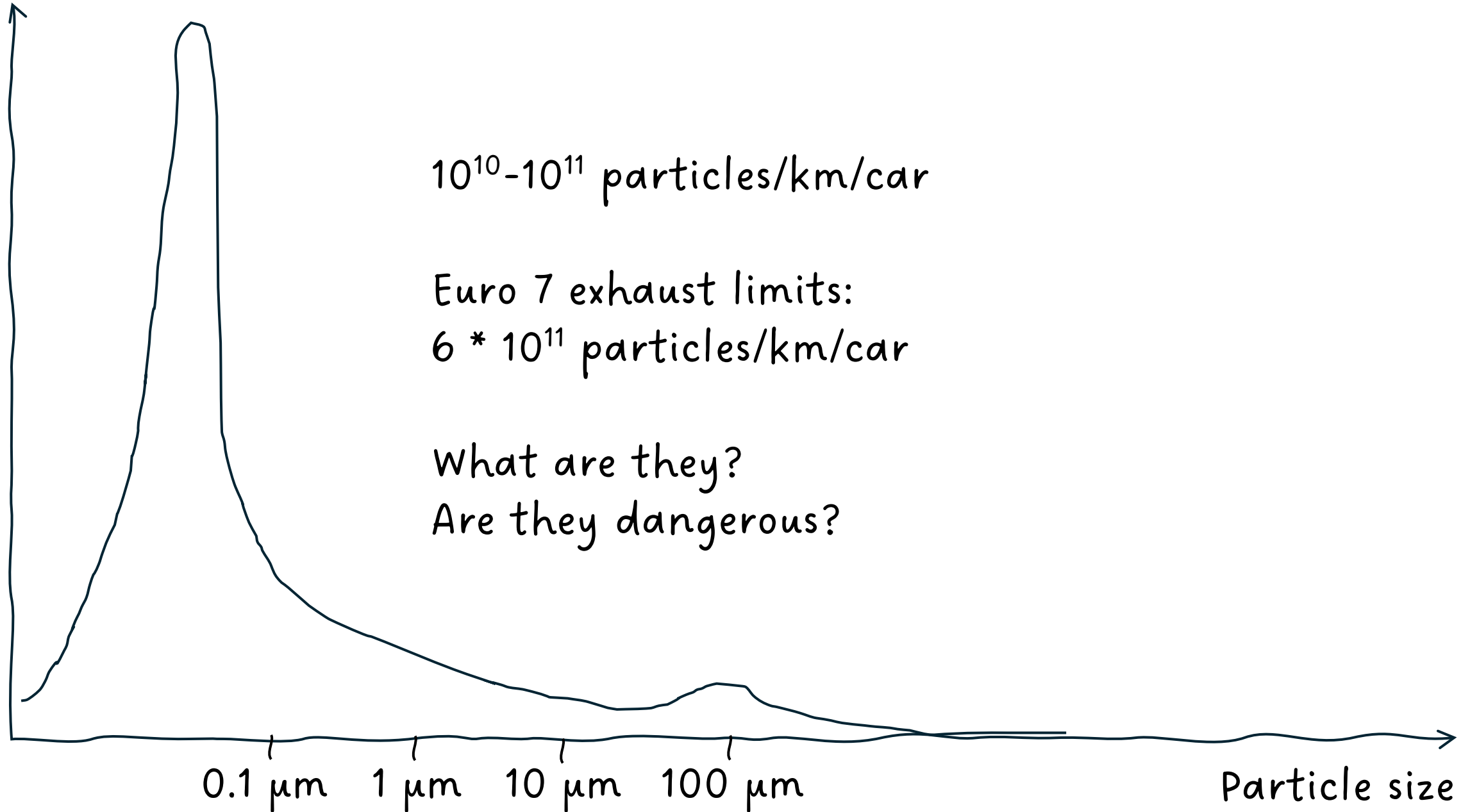


# Chemical Origin of Tyre Nanoparticles in a Tube Furnace

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Number



normal driving. Therefore, in order to account for the formation of polymer degradation products, we postulate that local temperatures in small areas of the contact patch must greatly exceed the temperature of the bulk tread, and even approach pyrolysis temperatures. Temperatures hot enough to cause polymer degradation would also volatilize the extender oil, which is a high molecular weight hydrocarbon material. Indeed, the thermoparticulation experiments support this hypothesis by showing that particles are released from the rubber surface at temperatures greater than 180°C.

differently than the 320 and 640 nm particles. Fig. 4 shows the mean particle diameter of selected 80 nm particles after being conditioned at temperatures from 50 to 300 °C. The particle diameter appears to decrease linearly with increasing temperature. If the particle material had contained only one single substance then the response curve would have been more S-shaped. Hence, the particles most likely contain several semi-volatile components with a wide range of vapor pressures.

internally and externally mixed (see Fig. S8 and S9†). It is not possible to differentiate the tire and asphalt components of these particles, and thus must be referred to as a collective TRWP. The nanoparticles appear primarily to be organic based on the CS-ELPI results (>95% removal in the CS), but there do appear to be non-organic signals in the EDX spectrum, which are distinct from the micron-sized TRWP materials.

1978

Cadle & Williams  
Furnace  
Tyres emit ultrafines

2006

Dahl *et al.*  
Tyres on track  
Volatile

2024

Haugen *et al.*  
Tyre in drum  
Volatile & organic

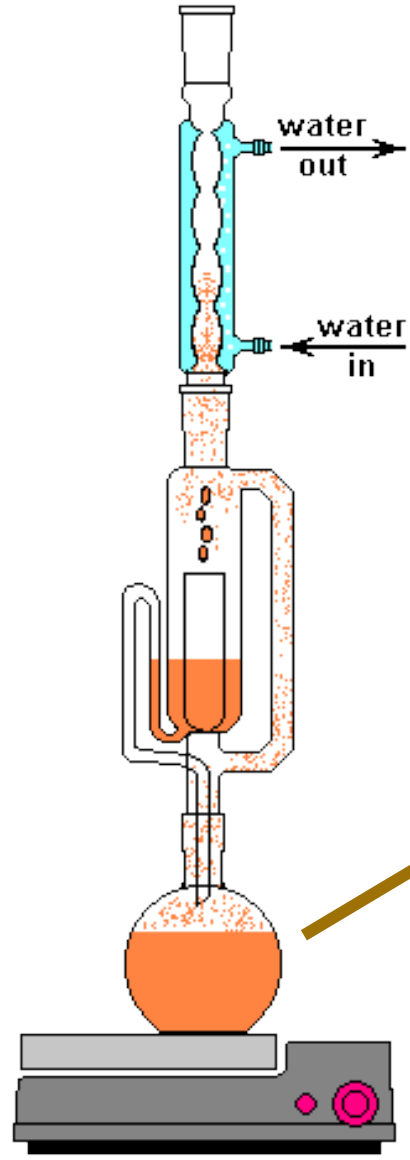
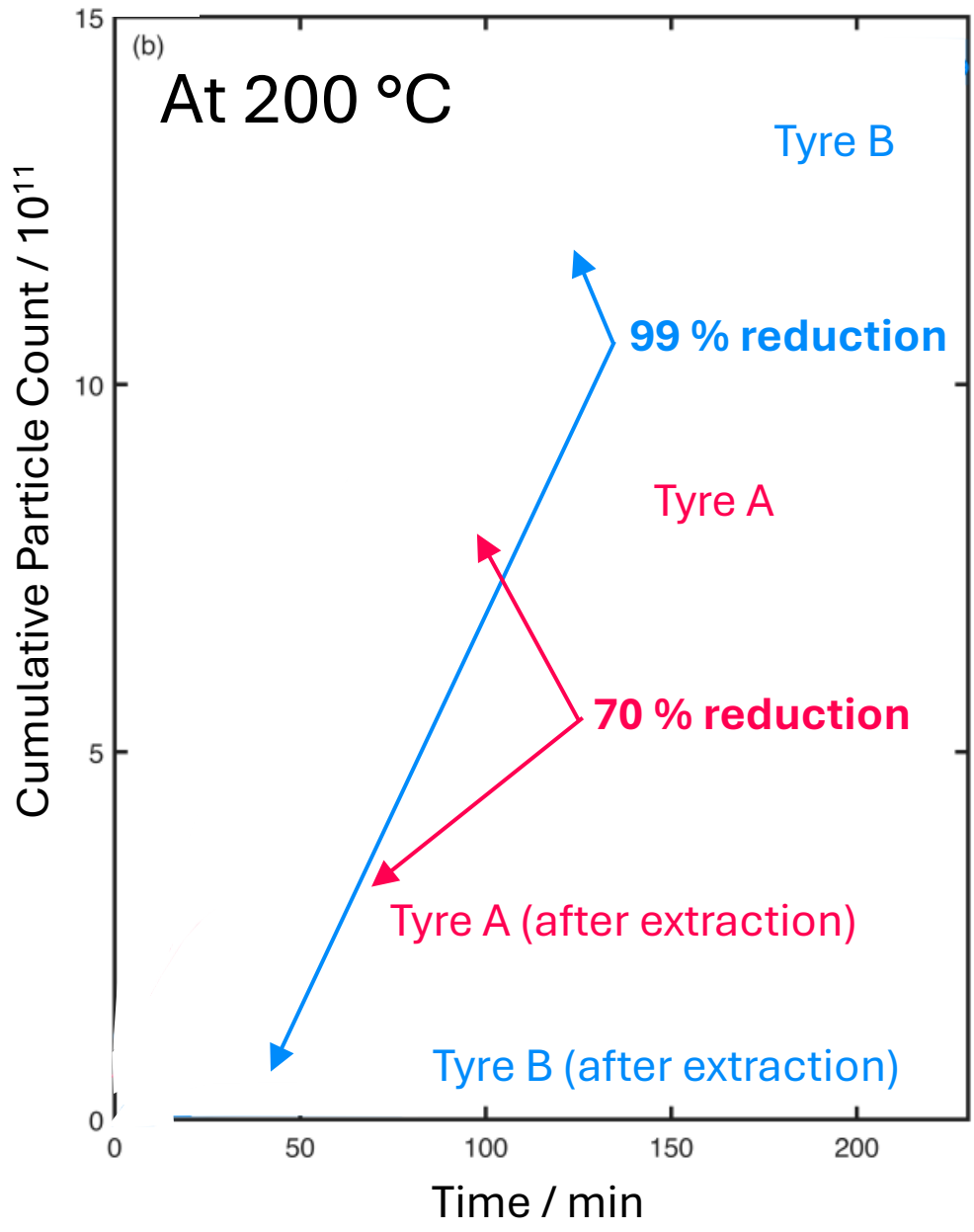
Emerging consensus:  
Evaporation and condensation of something

Evaporation of what?

# Tyre extender oil

- Mineral oil
- ~ 20 % of tyre tread (passenger cars)
- Used for:
  - Processability
  - Filler (cost reduction)





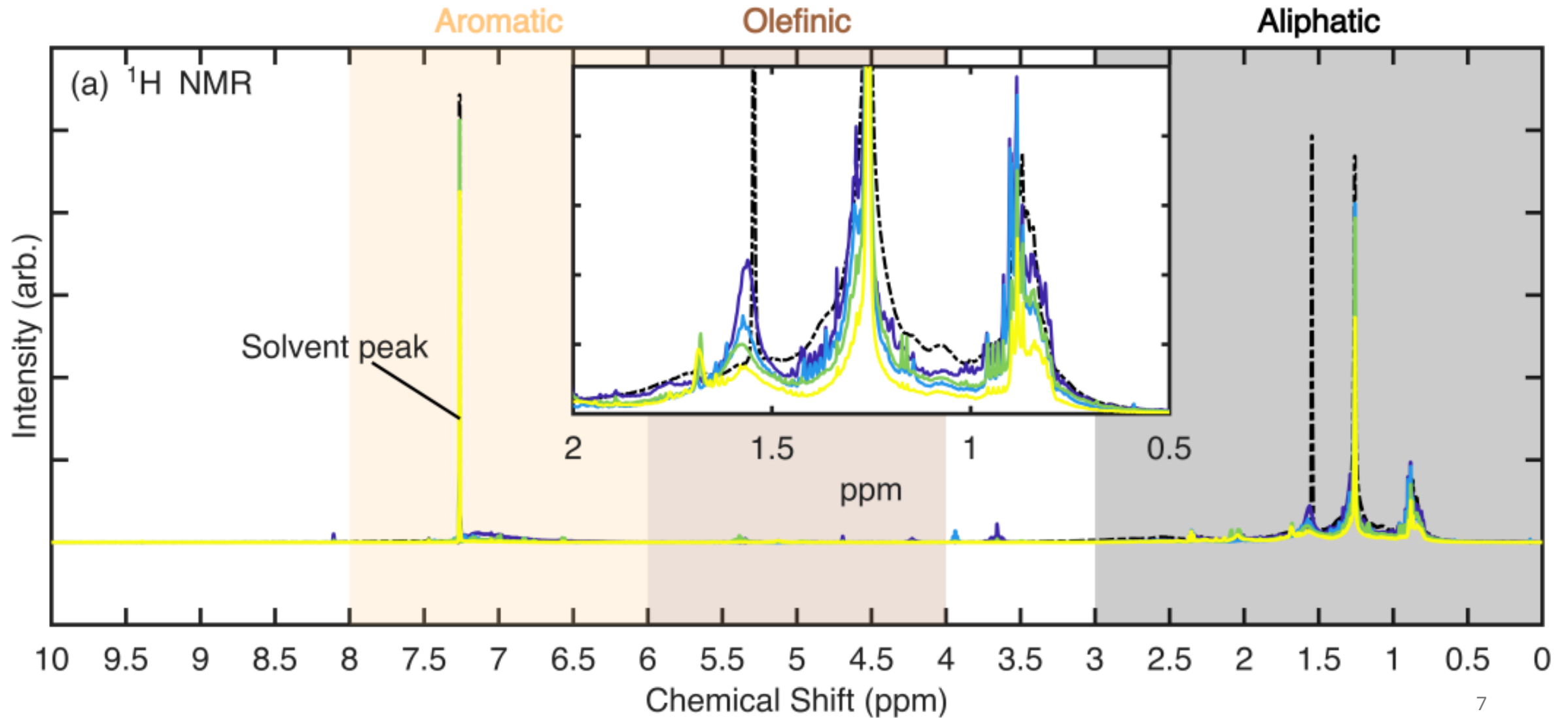
Mass losses during extraction:

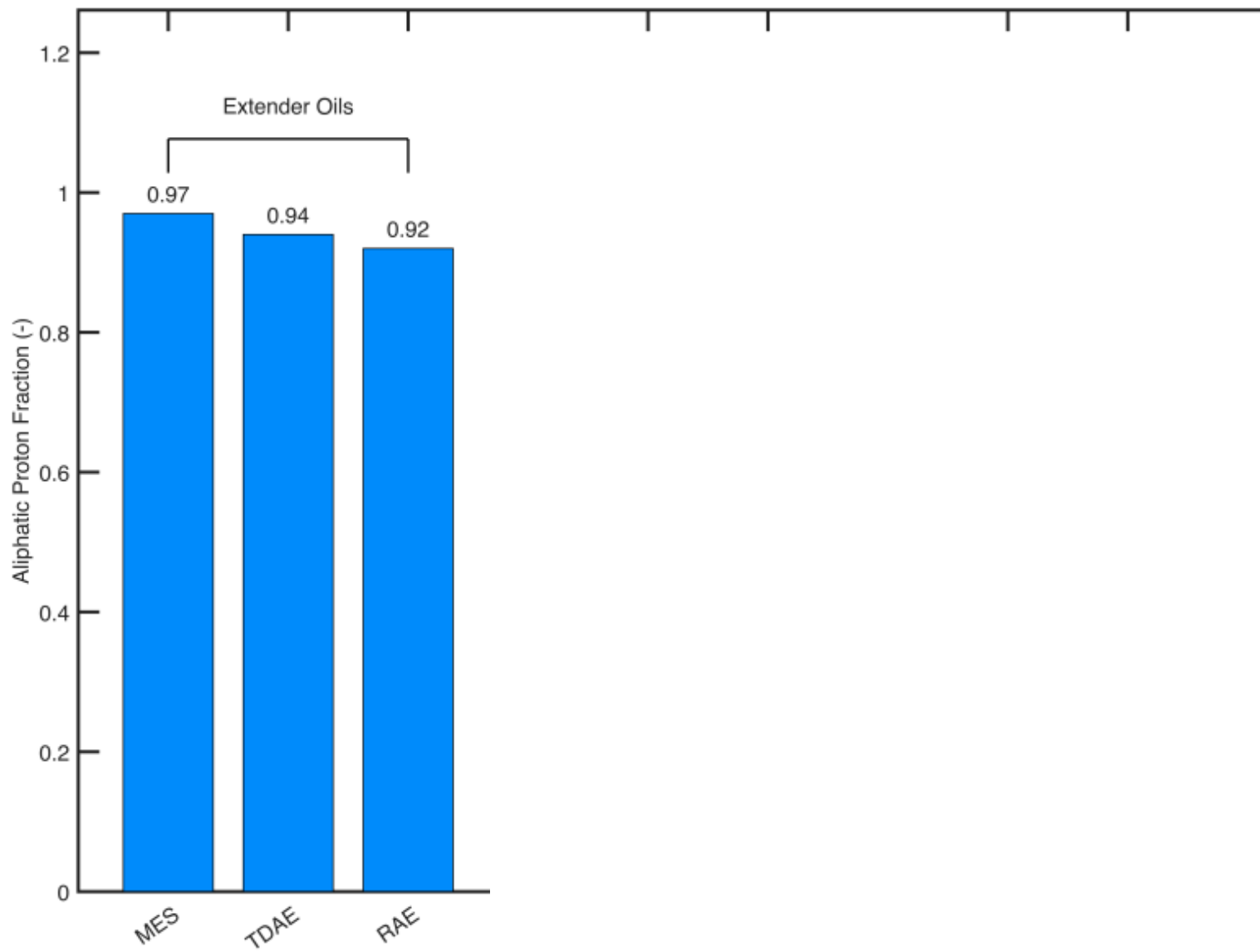
Tyre A: 15 %

Tyre B: 26 %

# $^1\text{H}$ NMR

— Tyre A Nanoparticles





## Conclusions

- Tyre nanoparticles emitted at 200 °C are likely derived from extender oil (or something similar)
- Link to real-world emissions remains unclear (hotspots may even approach pyrolysis temperatures)
- Tyre extender oil can offer a practical surrogate for toxicological studies of tyre nanoparticles

## **Funding**

EPSRC Centre for Doctoral  
Training in Aerosol Science



**Engineering and  
Physical Sciences  
Research Council**

## **Contact me**

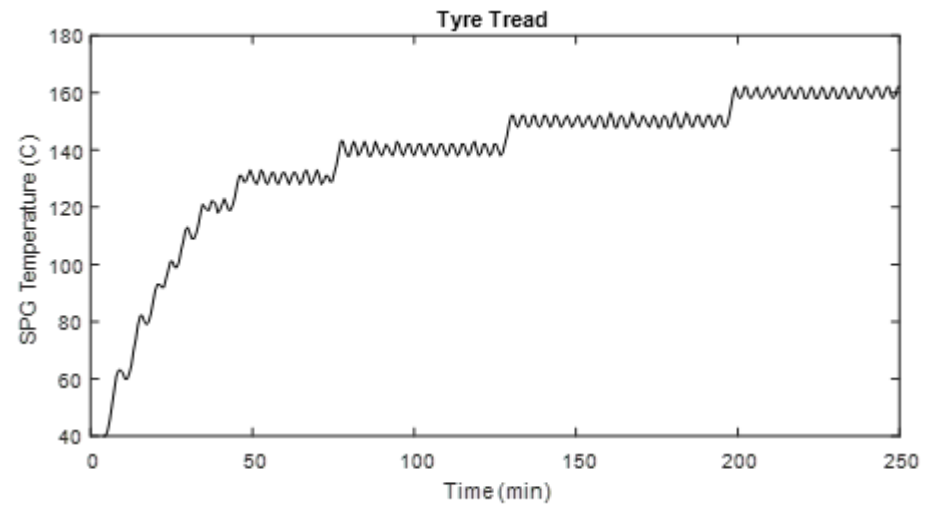
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# In a tube furnace

## Tyre tread



# $^1\text{H}$ NMR

----- RAE Extender Oil    ———— Pirelli TT Nanoparticles    ———— USTMA TT Nanoparticles  
——— Pirelli TT Extract    ———— USTMA TT Extract

