Imperial College London

Natural Environment Research Council

## 2024_56_MechEng_MM: Towards a mitigation strategy for tyre particulate emissions: mechanics of rubber particle generation

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Tyre emissions are an understudied aspect of the total particulate emissions from transport. In terms of grammes of particulate emitted per mile driven, tyre emissions are comparable to tailpipe emissions. In addition, tyre particulate is the one emission that is not reduced with the transition to electric vehicles, which successfully prevents tailpipe emissions and improves brake emissions by the use of regenerative braking.

Our current understanding of tyre-particulate matter (PM) is not very well developed; there is a lack of basic understanding of how tyres wear, what types of wear debris are generated, what the main influencing factors are and how harmful these particles are to our health and the environment. Consequently, knowledge of how to prevent the emission of tyre particulate matter is lacking. Whilst scientists have proposed a range of potential solutions to the tyre particle problem (ranging from the use of autonomous vehicles, and controlling access to specific roads to utilising alternative materials and introducing new business models for tyre manufacturers) this lack of basic understanding currently halts the implementation of any solution.

To address this, we propose a research plan in which we investigate the basic mechanisms of rubber and rubber particulate generation and the effects of these particles on the aquatic environment.

Key aspects of the research include:
• Initial explorative investigation of the degradation kinematics of tyre rubber using a traction machine
• Characterisation of unworn and worn rubber as well as the the wear particulates using microscopy, FTIR and Raman spectroscopy, nano-indentation and particle size analyser
• Assessment of the aqueous release of chemicals from the tyre particles using wave simulator experiments

Tyres wear due to the combined rolling and sliding interaction with the road surface, resulting in a combination of abrasion and fatigue. Our recent work has shown that the damage evolution of tyres is driven by the total thermo-mechanical energy input into the rubber: due to the rubbing contact between tyre and road a surface layer with reduced properties develops. We will experimentally investigate the elementary mechanism of degradation of the surface layer leading to particle formation and elucidate the key mechanical aspects involved. We will assess whether the wear particles become airborne, adhere to the road surface or develop as an unbound fraction. Environmental effects of the generated wear particles will be assessed by submerging the particles in a water bath to assess migration and leaching of volatile components.

Developing this knowledge is key to the implementation of innovative solutions, and we will liaise with The Tyre Collective and scientists at Imperial, including Prof Bob Shorten, Prof Mary Ryan, Dr Mark Stettler, Prof Astolfi), who are currently working on developing solutions to the tyre wear problem, to ensure our findings can be implemented in their work.