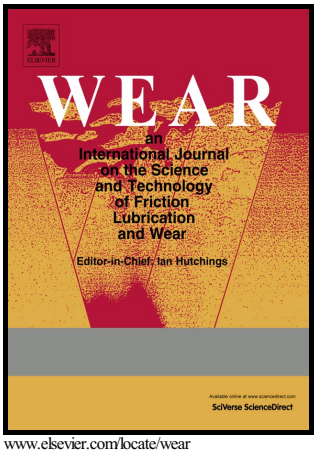

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ABSTRACT
With regard to airborne particles with an aerodynamic diameter of less than 10 μm (PM_{10}), in countries in the European Union, the mass of brake emissions equals approximately 8-27% of the total traffic-related emissions. Using a research methodology combining tests at different scale levels with contact mechanics simulations and PM_{10} chemical characterization, the REBRAKE EU-financed project had the following aims: i) to demonstrate the possibility of reducing the PM_{10} fraction of the airborne particulate from brake wear by 50 wt.%; ii) to enhance the general understanding on the physical and chemical phenomena underlying the brake wear process. The results achieved so far indicate that it is possible to design a disc brake system for a European standard car affording at least a 32 wt.% PM_{10} emission reduction using a standard European pad and a heat-treated rotor. A further reduction to 65 wt. % PM_{10} emission could be achieved with NAO pad material and the same heat-treated disc.

KEYWORDS
Brakes; non-exhaust emissions; airborne particles; simulation; pin-on-disc test; dynamometer test

INTRODUCTION
Particles generated by road traffic originate not only from engine exhaust emissions, but also from wear processes occurring in brakes as well as between tyres and the road surface. In particular, a vehicle disc brake consists of a rotor and pads that are pressed against each other in order to reduce the vehicle speed by the friction drag generated at the contact interfaces. During the braking event, the friction pair wear out generating particles: the airborne fraction can penetrate the human body in many ways, including contact with the skin, breathing, and eating with potential adverse health effects [1]. The concentration of particulate matter (PM) continued to exceed the EU limit and target value in large parts of Europe in 2014 for which a total of 16% and 8% of the EU urban population was exposed respectively to PM_{10} and $PM_{2.5}$ (PM fraction consisting of particles with aerodynamic diameter of less than 10 μm and 2.5 μm respectively) levels above the daily limit value; considering the stricter WHO AQG values, the fraction of population affected changes to 50% and 85% respectively for PM_{10} and $PM_{2.5}$ [2]. Whilst exhaust gases from road transport are monitored and regulated by European legislation, little interest has been shown so far in PM originating from the wear of brakes, tyres and other non-exhaust emissions that altogether may amount to 50% by mass of the total ones [3], [4] and its relative contribution is expected to increase due to the legislation driven reduction of aerosols from vehicle combustion processes [5]. According to recent investigations [6], 16-55% by mass of non-exhaust emissions are generated by brake wear, and it was estimated that 50% of the brake wear particles become airborne, 80-98% of which