Microstructure and Oxidative Behavior of Soot from Euro IV Diesel Engine

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Reducing the exhaust emission of automobiles is one of the most important measures in environmental protection. US and European legislations have introduced particulate standards for diesel engines and have tightened the standards over the years. Nowadays, engine manufacturers enhance the effort in developing new low emission engines to fulfil the new particulate standard that will be applied in 2005. The rapid development in engineering requires an updating investigation of soot particulates emitted by new low emission engines. Recently, we studied the morphology and microstructure of soot of an optimised low-emission EuroIV test diesel engine, equipped with a double step controlled charging and an external controlled cooled exhaust gas recirculation.

The high-resolution image in Fig. 1 shows typical micro-morphology of soot from a EuroIV test motor (F-soot). The particle shows neither defined structure nor regular shape. The basis structure is the defect-rich and bended graphene layer. Circle like contrasts along the periphery of the particle are found, which could be identified as fullerene molecules and fullerenoid clusters. This fullerene-like soot may be the result of the optimised mixing behaviour of air and diesel fuel (air/fuel >1.3) in the combustion chamber. Figure 2 shows the results of a TG analysis in 5 % O_2 in N_2 for the Euro IV soot sample, compared with the results of black smoke of a EuroIII diesel engine (G-soot). For both samples the produced gas analysis shows that the main product is CO_2 with a minor amount of water. No other gas phase products were observed. The TG signal for both samples remains nearly the same until about 600 K where the F-soot begins to rapidly loose mass. The rate of mass loss for sample the F-soot reaches a maximum at 833 K, but goes to zero at about 870 K. G-soot also begins to evolve CO_2 at about 600 K, but the concentration remains relatively low until about 680 K. The mass of the G-soot continues to decrease until 965 K when it reaches 0.

Our investigations reveal that through the measures taken to decrease soot emission, the new, low-emission EuroIV diesel engine produces carbon particulate consisting of fullerenic primary particles. The optimised combustion conditions prevent the formation of larger, more stable spherical soot particle. The EuroIV engine soot exhibits a highly defective microstructure and is much easier oxidised, making its elimination through engine-internal oxidation possible.

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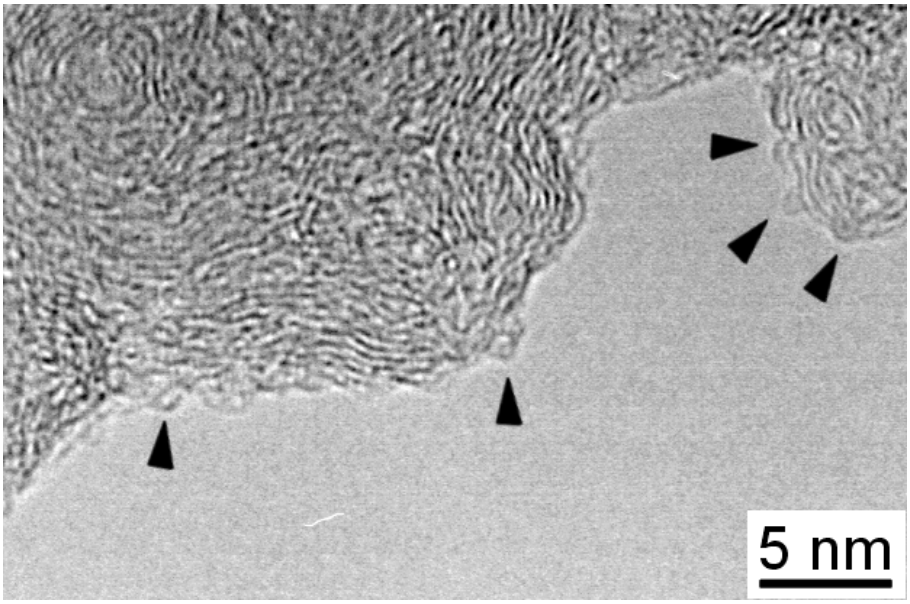

Fig. 1: EuroIV soot agglomerate with undefined structure. Circular contrasts due to fullerenoid-like structure on the periphery are arrowed.

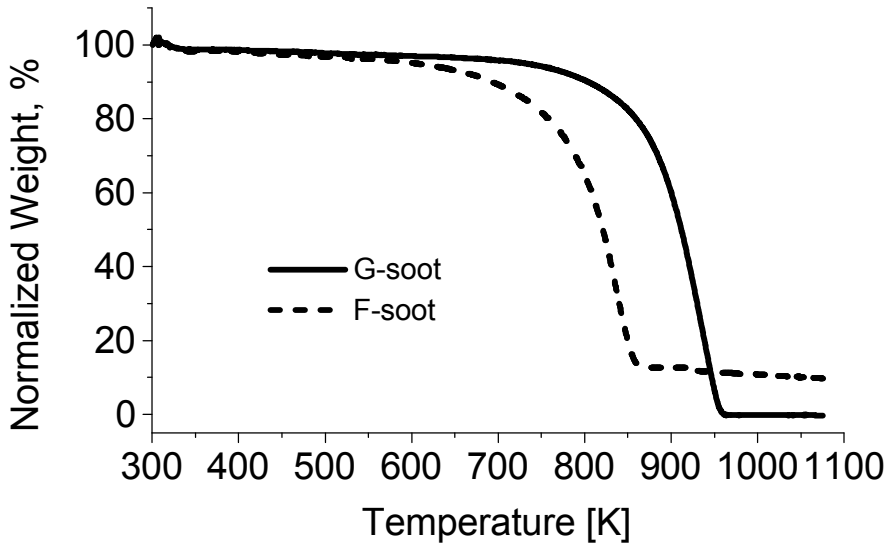

Fig. 2: TG analysis in 5 % oxygen in nitrogen for G-soot (lined) and F-soot (dashed).