Investigation of the nanosized coal particles formation and their role in combustion of methane-air gas mixtures

S.V. Valiulin[1], A.M. Baklanov[1], S.N. Dubtsov[1], A.A Onischuk[1], P.V. Koshlyakov[1], V.V. Zamaschikov[1], A.A. Korzavin[1] and D.Yu. Paleev[2]

[1]Voevodsky Institute of Chemical Kinetics and Combustion SB RAS, Novosibirsk, 630090, Russia
[2]Institute of Coal SB RAS, Kemerovo, 650065, Russia
Key words: coal, nanoparticles, aerosol formation, explosion risk.
Presenting author email: valiulin@kinetics.nsc.ru

Mechanism of nanoparticles formation during coal grinding has been investigated. Particles number concentration and size distribution in the face of the coal mine with a coal-plough machine under operation have been measured with diffusion aerosol spectrometer. 90% of the aerosol particles were found to be below 200 nm in diameter. Moreover there are modes in the size distribution, corresponding to 20 and 150 nm (Fig. 1 and Fig 2). TEM analysis showed that the 1st mode belongs to individual particles, while the 2nd – to aggregates of the individual particles.

To understand the mechanism of these nanoparticles formation, the kinetics of gaseous compounds and nanoparticles emission during coal grinding in a flow mill has been studied. The particles size distribution and morphology, produced in the mill, were shown to correspond qualitatively with the nanoparticles in the mine. GC-MS analysis showed that the major nanoparticles components are alkanes and polyaromatic compounds with 3 – 4 condensed rings.

Investigation of the gaseous compounds emission showed that methane and ethane concentration in the gas flow, coming out of the mill, can reach 10 and 1% respectively. The concentration of organic particles is about 100 g/m^3. Comparison of the nanoparticles number concentration in the mine face and at the mill outlet allows one to conclude that the concentration of organic aerosol in the mine face reaches 1 g/m^3.

To investigate the coal aerosol influence on the combustion of gaseous mixtures the 10 l the standard "constant volume combustion bomb" was used. The explosibility of lean methane-air was shown to increase greatly in the presence of coal nanoparticles. This is demonstrated as in the increase of maximal pressure value, as in the significant increase of the rate of pressure increase. The explosive range of such aerosol was measured to be 120 g/m^3.

The results of our investigation allow us to conclude that the source of nanoparticles are organic compounds in the coal, emitted to the gas phase during local rock heating at coal grinding. Thus, the organic aerosol nanoparticles in the face can influence significantly on the explosion risk.

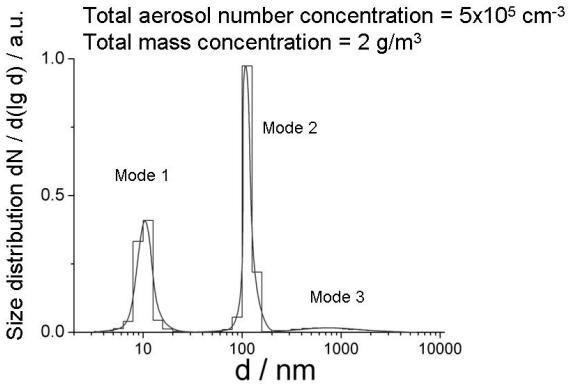

Figure 1. Aerosol particles size distribution, measured in the face of the mine "7-th November" with a coal-plough machine under operation.

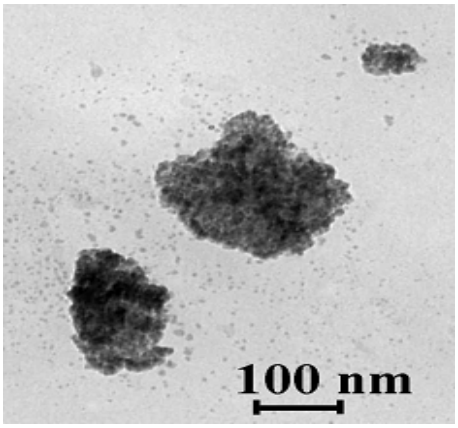

Figure 2. TEM image of aerosol particles collected in the face of "7-th November" mine with a coal-plough machine under operation.

The reported study was funded by RFBR according to the research project №16-33-00012.