Ship particulate exhaust characterization: microstructure, elemental composition, surface chemistry

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IVL sampling M/V Atlantic Conveyor



Possible climate impacts which are still least defined in comparison land-based with transport

Ship emission particulates can act as nuclei for the formation cloud droplets that may of produce ship tracks in the MBL

Water-soot interaction is one of the important parameters defining ability of the soot to form contrails and ship tracks

The starting point for evaluating the effect of ship emission on environment is to characterize its properties (structure, chemical composition etc)

Introduction.

Particulate emission of transport systems and its impact on atmosphere is currently acknowledged to be the largest source of uncertainties in understanding the transport impact on the regional environment and global climate. In harbors areas ship emission residuals particles are considered as dangerous pollutants with respect to human health. However, until now seagoing ships are not subject to the stringent air quality legislation applied to land-based transport, and ship particulate exhaust is still remaining without comprehensive characterization.



engine Kincaid B&W 6L90

38 h of sampling in cruise June 14, 2007, Celtic Sea, English channel, and North Sea (EU proj. QUANTIFY) 25 m behind the engine

Heavy Fuel Oil (HFO) containing ash (0.03 wt%), Sulfur (1.9 wt%), Vanadium (0.011wt%), Nickel (0.004 wt%), and Calcium (0.0003 wt%)

Sampled at the end of the pipe through a hole in the exhaust manifold of an Atlantic container ship burning heavy fuel oil.

Microstructure of ship particulate exhaust

Microstructure and chemical composition of ship particulate exhaust was performed by Transmission Electron Microscope (TEM) JEOL 2000FX joined with Energy-Dispersive X-ray spectroscopy (EDS). Selected Area Electron Diffraction (SAED) was applied in order to identify crystallinity of the ship engine exhaust residuals.

prismatic crystals





Compounds: CaO, CaSO CaCO. Sometimes. Ni₂S Ni₃S

Char particles have spherical shape and their diameters are in the range 0.2 - 1.2 µm. They are formed from unburned fuel by subsequent pyrolysis, oxidation and

Surface functional group analysis (FTIR) and water uptake

Surface functional groups are responsible for water uptake properties of ship exhaust particulates. Fourier Transform Infrared spectroscopy is a powerful tool in surface chemistry characterization. Experiments were carried out on Brucker Equinox 55 spectrometer in the region 400-4000 cm⁻¹ (resolution: 4 cm⁻¹). Water adsorption isotherms are performed at room temperature (gravimetric method)



Heavy fuel oil combustion residuals exhibit large verity of shapes and chemical forms. The particles can be separated into three groups: soot-type particles, char particles and mineral/ash particles. The main charateristic of HFO residuals is the highly pollution of soot-type primary particles with nickel and vanadium (inner core insertion). Thus vanadium and nickel can be used as markers of HFO burning. The second group is presented by char particle which are found only in case of HFO burning. The third group of particles corresponds to mineral/ash particles containing mainly Ca and V.

Cr particle

REFERENCES

CaO

on with hyd va, N. M. P

sion freezing of water and possible a, E. Kireeva, N. Persiantseva, T. Khokhlova, N. Shonija, V. Tis ian, Atmospheric Research 90 (2008) 326–337



mineral/ash particle containing Ca, Ni, V,

n of particulate matter and gaseous emissions from a large shi i, Erik Fridell, Olga Popovicheva, Benjamin Demirdjian, Victoria andro Faccinetto and Cristian Forse, Atmospheric Environment 43

Char particles