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Separation and qualitative analysis of suspended matter in jet fuel

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Abstract

Suspended matter in jet fuel was separated by filtration and analyzed using scanning electron microscopy, energy-dispersive X-ray spectrometry, X-ray diffractometry, infrared spectrophotometry and gas chromatograph-mass spectrometry. The results showed that the components in the suspended matter include alkanes, esters with long molecular chains and multi-substituents, alcohols, ketones, alkenes and heteroatomic compounds containing nitrogen and sulfur. This work will assist in the ultimate determination of the chemical composition of the suspended matter and an understanding of its mode of formation.

Keywords: Analysis; Suspended matter; Jet fuel

1. Introduction

Jet fuel is used in both civil and military aircraft and its quality directly effects aviation safety. Although jet fuels produced in China are relatively clean some do contain suspended matter. Suspended matter increases wear and tear of precision parts in jet engines, clogs fuel equipment and causes a range of mechanical engine malfunctions. A comprehensive chemical analysis of the suspended matter in jet fuels is necessary so as to obtain an understanding of its mode of formation.

Some studies on the composition of jet fuel suspended matter have recently been reported. Zheng et al. [1] used energy-dispersive X-ray (EDX) spectrometry and energy-dispersive X-ray fluorescence (EDXRF) to analyze the elemental composition of suspended matter in jet fuel. They concluded that most of the compounds in the suspended matter contained the elements Fe, Na, Ca, Al, Mg, O, Cl, and S. Tao et al. [2] studied fibre-like suspended matter in jet fuel by optical microscopy and Fourier transform infrared spectrometry and found this material to be a mix of natural and synthetic fibers. Pardede and Batts [3] analyzed sediment by infrared spectroscopy, gas chromatography-mass spectrometry and elemental analysis. They showed that the sediment in their particular jet fuel sample was aluminum citrate, and originated from microbiological activity at the fuel-water interface. Pedley and co-workers [4] used infrared spectroscopy, gas chromatography-mass spectrometry and mass spectrometry to analyze sediment formed during the ambient storage of petroleum diesel. They concluded that non-basic nitrogen compounds have been found to be important constituents of the fuel sediment, and the above were useful for sediment analysis. In addition there have been several more general studies on the stability of jet fuel [5–9] and diesel [10].

In the present study, we aim to determine the main composition of suspended matter in jet fuel using modern analytical techniques such as energy-dispersive X-ray spectrometry, X-ray diffractometry, infrared spectroscopy and gas chromatograph-mass spectrometry. The results of the determinations will be useful for determination of the composition of the suspended matter allowing further studies on its properties and mode of formation.

2. Experimental

2.1. Samples and reagents

The jet fuels were stored in airtight glass containers in the dark for one year. All reagents used in this work were

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analytical reagent grade and were all redistilled prior to their use.

2.2. Separation and analysis

Particulate matter was separated from jet fuels by centrifugation and analyzed as follows.

(1) The jet fuel was filtered through a 0.025 μ microporous filter membrane. The filtration apparatus was designed according to the ASTMD 2068-97 standard.
(2) The suspended matter was Soxhlet extracted by *n*-hexane for 4 h and then ultrasonically extracted using dichloromethane for 20 min. The undissolved constituents in the suspended matter were further separated from the dichloromethane solution by centrifugation.
(3) Equal quantities of jet fuel without visible suspended matter were filtrated under the same conditions. The *n*-hexane and dichloromethane extracts of the filter membranes obtained were treated as experimental blanks of the corresponding analysis.
(4) The morphological structures of the suspended matter were observed and the elemental composition determined by scanning electron microscopy, energy dispersive X-ray spectrometry and low vacuum scanning electron microscopy.
(5) The *n*-hexane and dichloromethane extracts were analyzed by GC-MS. The parameters used were:
(a) The oven temperature was initially held at 50 °C for 2 min. Hereafter the temperature was raised with a gradient of 8 °C min^{-1} until reaching 280 °C at which it was held for 5 min. It was then raised again with a rate of 20 °C min^{-1} until the temperature reached 300 °C where it was held for 10 min.
(b) A HP-5 (30 m × 250 μm × 0.25 μm) GC column coated with 5% phenyl methyl siloxane was used.
(c) The carrier gas was helium at the flow rate of 1 mL min^{-1}. Samples were injected in splitless mode.
(d) An electron impact ionization voltage of 70 eV was used and a mass range of 33–600 amu was used in the mass spectrometer.
(6) The suspended matter and the extracted suspended matter were analyzed and compared using infrared spectroscopy.
(7) The extract residue was also analyzed by X-ray diffraction.

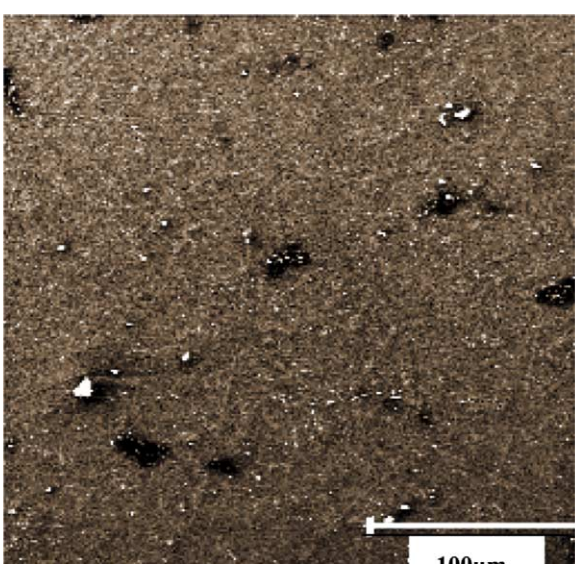

Fig. 1. Morphological structure of suspended matters in one drop of jet fuel sample

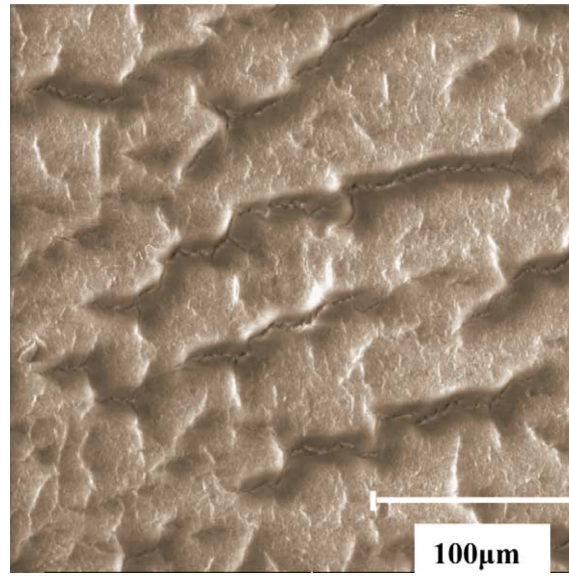

Fig. 2. Morphological structure of suspended matters in one hundred milliliter jet fuel sample

3. Results and discussion

3.1. Analysis of inorganic components in suspended matter

3.1.1. Scanning electron microscopy-energy spectrum analysis

The morphology was observed using a HITACHI S-530 scanning electron microscope with Link ISIS energy spectrum instrument and a XL-30 ESEM low vacuum scanning electron microscope. To observe the suspended

Table 1
Results of elemental analysis of suspended matters

Element	Content%	Element	Content %
C	37.88	Si	4.54
O	47.19	K	0.68
Na	0.76	Ca	3.82
Mg	1.04	Fe	2.72
Al	0.42	Ti	0.96