

# Analysis of Jet A-1 Deposits Containing Carbon Spheres and Nanostructures: Effect of Trace Metals and Heteroatomic Components

Pooja Sharma and Saptarshi Basu

Department of Mechanical Engineering, Indian Institute of Science, India

## INTRODUCTION

- Carbonaceous nanoparticles and carbon spheres form as a result of Jet A-1 thermal stressing by flask tests in the autoxidation regime (185-190) degrees Celcius.
- Spherical nanostructures and carbon spheres formation in the jet fuel is trace metal catalyzed.
- Heteroatomic jet fuel components contribute in the large mass species formation.

## RESULTS

- TEM and SEM micrographs are representative and illustrate numerous nanostructures and carbon spheres (Figures 1 to 5).
- Nanoparticles and carbon spheres form chain like pattern (Figures 1 to 5).
- Size distribution and average diameter of nanoparticles is 26.6 nm (Figure 3).
- HRTEM images show nanoparticles with metallic components (Figure 4).
- Interplanar spacing (d-values) measured for Jet A-1 deposits by HRTEM and XRD are in the range a) 0.12 to 0.20 nm and b) 0.29 to 0.36nm. d-spacing of jet fuel deposits correspond with few metals, carbon black and soot.
- ICP MS analysis identified Cu, Zn, Fe and Al in the Jet A-1 deposits.

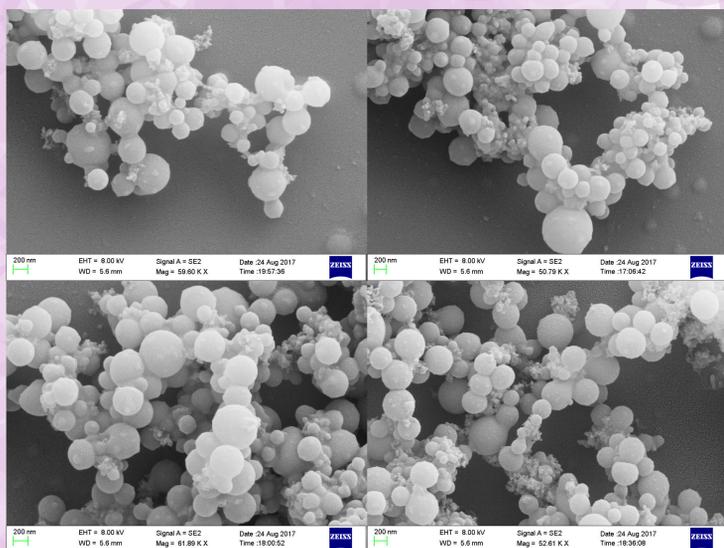


Figure 1: SEM micrographs of Jet A-1 deposits: Carbon spheres and nanostructures

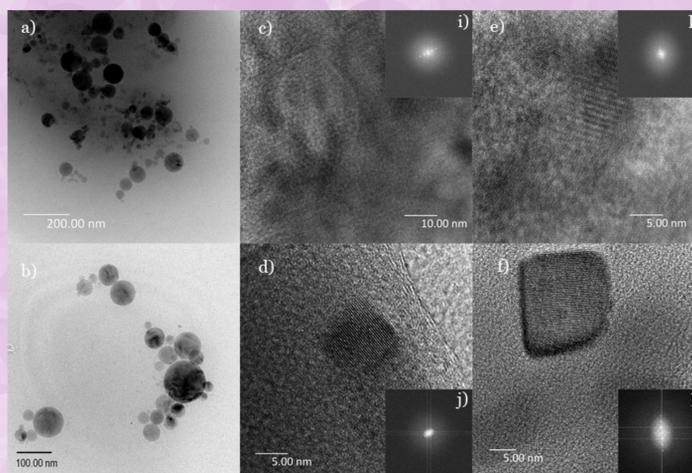


Figure 4: a), b) Jet A-1 deposit nanoparticles, c) to f) HRTEM micrographs of nanoparticles with lattice fringes and i) to l) are FFTs of the HRTEM of c) to f) respectively

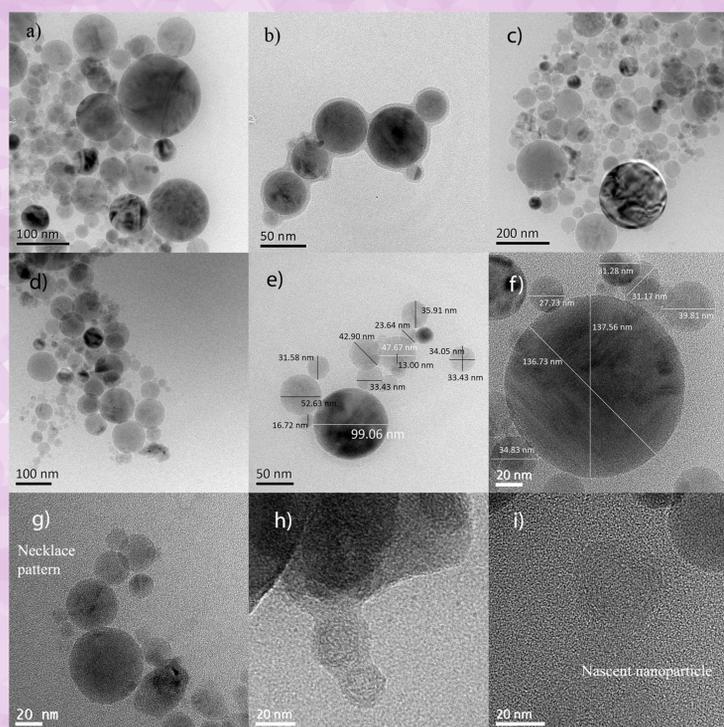


Figure 2: Jet A-1 deposit nanoparticles forming necklace pattern

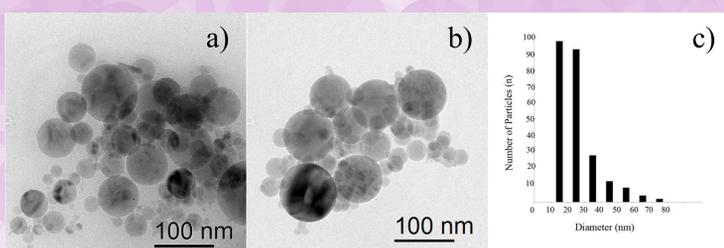


Figure 3: Jet A-1 deposit nanoparticles and size distribution

- ESI MS spectrum shows a mass difference pattern of 43 Da (Figure 7a) which suggests free radical mechanism and propyl radical generation.
- Large mass species (upto 1000 Da) are recorded by ESI MS spectrum in the thermally stressed jet fuel (Figure 7a).
- FTIR spectra support oxygenated compounds formation in the thermally stressed samples (Figure 7b).
- Carbon spheres formation suggest condensed phase reactions.
- Jet A-1 is a potential hydrocarbon source for carbon spheres synthesis without any externally added catalyst.
- Jet A-1 deposit formation in the autoxidation regime depends on fuel composition. Heteroatoms and trace metals catalyze spherical carbonaceous particles generation.

Figure 7: a) ESI MS spectrum of thermally stressed Jet A-1, and b) FTIR spectra of unstressed (A0) and thermally stressed Jet A-1 (A24S)

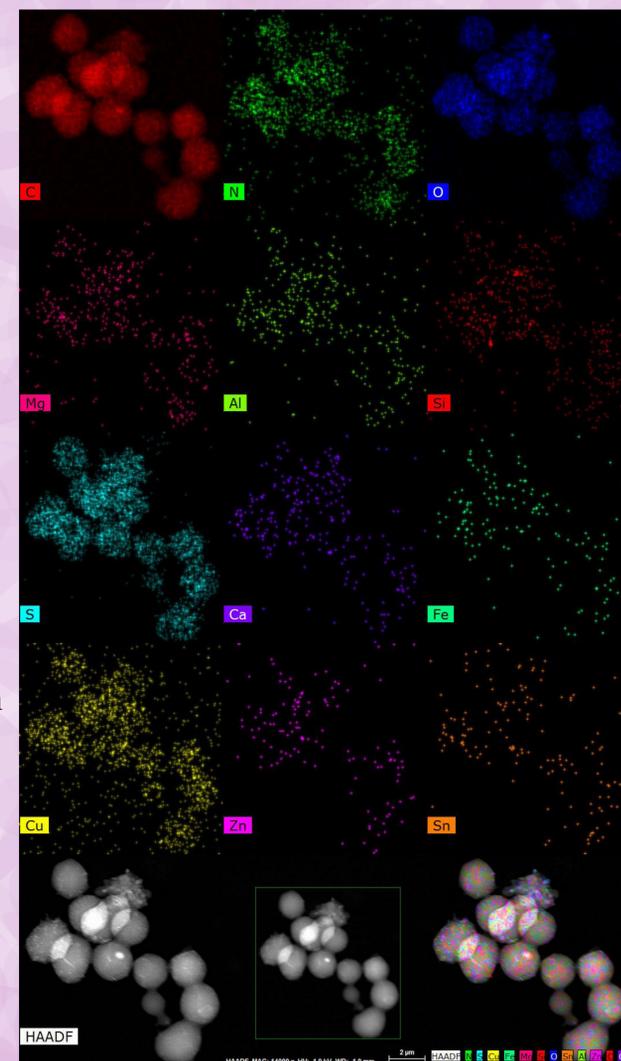
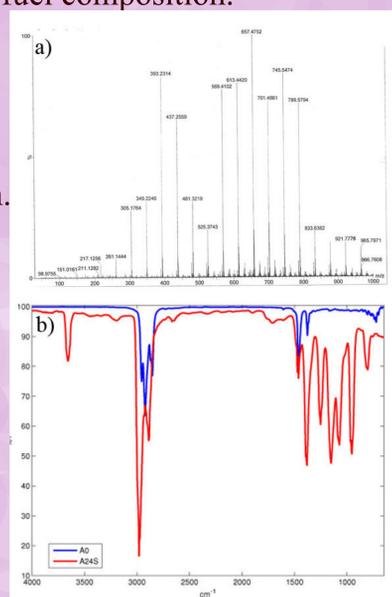


Figure 5: STEM HAADF elemental maps showing Jet A-1 deposit carbon spheres with multiple trace metals and heteroatoms

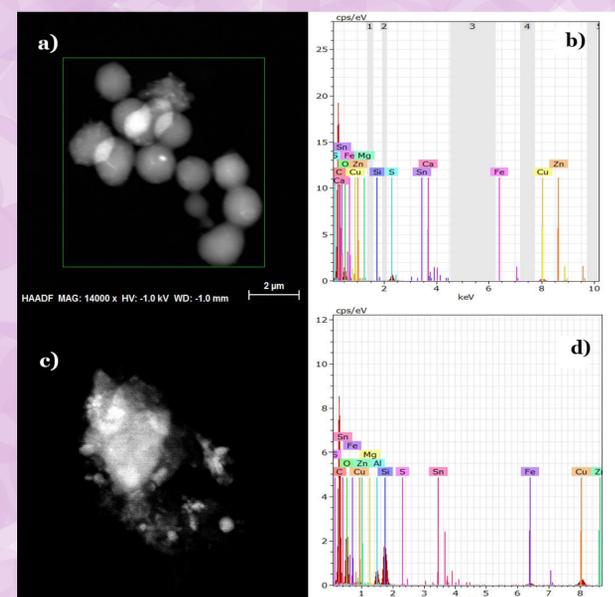


Figure 6: TEM EDS of Jet A-1 deposits