



Does organic carbon hold micrometeoroids together?

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The cosmic dust input into the Earth's atmosphere has been estimated at 28 tonnes per day. However, the models behind this estimate do not include fragmentation. If the particles fragment significantly, the input rate of dust would be considerably higher. Millimetre sized meteoroids have been observed to fragment. If this is true for the majority of the cosmic dust particles that enter the Earth's atmosphere (size range 10 micron to 1 mm), it would make a difference to the rates of ablation of these particles and our understanding of the meteoric inputs into the Earth's mesosphere. Fragmentation would result in a broader size distribution and a greater number of 0.2 – 1.0 micron-sized particles sedimenting into the stratosphere.

The Meteoric Ablation Simulator (MASI) is a chamber for investigating the ablation of volatile species from meteoroid proxies. Here, we run it at relatively low temperatures to investigate the pyrolysis of hydrocarbon compounds. It has been proposed that organic carbon compounds act as a glue to hold the grains within micrometeoroids together. The carbon compounds are thought to be tarry, refractory kerogen compounds similar to those found in terrestrial oil shale. At moderate temperatures, these compounds pyrolyse into species such as butane and pentane.

The MASI employs a heated surface, the temperature of which can be varied from 300 to 1200 K. Once the surface is up to temperature, particles are dropped onto it. The ablating carbon-containing compounds are detected by mass spectrometry. The majority of the ablated carbon combusts to CO₂. Measuring the rate of CO₂ production as the particles are exposed to specific temperatures enables the temperature-dependent rate of pyrolysis of the carbon compounds to be measured.

To measure the effect of the removal of the carbon compounds on the strength of the particle, particles are subjected to yield stress tests in an atomic force microscope (AFM). Particles that have been flash heated, breaking bonds in the hydrocarbon glue, are expected to be more fragile.

Powdered meteorite samples (2% organic carbon) lose carbon over a broader range of temperatures than powdered oil shale (15% organic carbon). The effective activation energies measured for this pyrolysis are low – about 90 and 60 kJ mol⁻¹ for the oil shale and CM2 meteorite, respectively. This is likely a combination of 1) particles not reaching the surface temperature due

to evaporative cooling and 2) the complexity of the reactions occurring in the carbonaceous particles as they heat. Analysis of TGA traces for oil shale samples give a higher effective activation energy of 191 kJ mol^{-1} . This value agrees with other TGA analyses of oil shale. In both cases, the biggest loss of carbon happens at around $700 - 800 \text{ K}$. AFM yield stress tests show evidence of fracturing, but so far only at pressures too high to be relevant for fragmentation in the atmosphere.