Infrared-Absorbing Carbonaceous Tar Can Dominate Light Absorption in Heavy-Fuel-Oil PM

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Heavy fuel oil (HFO) is widely used in the open ocean and Arctic, and is known to emit substantial amounts of black carbon and polyaromatic hydrocarbons. However, we show here that those light-absorbing species do not comprise the bulk of the direct climate forcing by HFO emissions. Our characterization of a marine engine shows that a previously unidentified particle type, insoluble and infrared-absorbing tar, dominates total light absorption at low engine loads. Tar particles have a higher fraction of sp^3-bonded carbon than BC, and consequently a high Angstrom absorption exponent (AAE) of ~2.0 at wavelengths 370–1000nm. As this tar is refractory, thermal–optical analysis cannot be used to distinguish it from BC; its climate effects are most accurately quantified by direct light-absorption measurements taken at specific wavelengths. Field observations suggest that tar already contributes to accelerated Arctic snow melt, an effect which may be magnified as Arctic shipping continues to intensify.