

AccuTOF-DART analysis of motor oils

Introduction

DART can characterize additives in lubricating oils directly without sample preparation. The additives generally produce a strong signal without interference from the base oil. However, complementary information about nonpolar components of the base oil can be obtained by O_2^- attachment chemical ionization, a simple analysis that can be easily and rapidly carried out with changing any hardware on the AccuTOF-DART mass spectrometer system.

Experimental

All mass spectra were acquired with a JEOL AccuTOF-DART mass spectrometer equipped with a DART-SVP ion source.

Additives in motor oil were analyzed by dipping the sealed end of a melting point tube into each oil sample and suspending the tube in the DART gas stream. The DART was operated in positive-ion mode with helium DART gas and a gas heater temperature of 400°C. The mass spectrometer parameters were: RF ion guide voltage: 600V, ring lens = orifice 2 = 5V, orifice 1 = 20V.

The base oil was analyzed by diluting 10 μ L of oil into 300 10 μ L of hexane. The DART was operated as a source of O_2^- in negative-ion mode with helium gas. The AccuTOF mass spectrometer was operated in negative-ion mode with the RF ion guide set to 700V, ring lens = -3V, orifice 2 = -5V, and orifice 1 = -12V. Samples in hexane solution were rapidly aspirated from a narrow-diameter capillary (PCR pipette capillary) directly into orifice 1 (Figure 1). Rapid expansion of the solution into vacuum stabilized the weakly-bound oxygen adducts $[M + O_2]^-$ for the nonpolar base oil components.

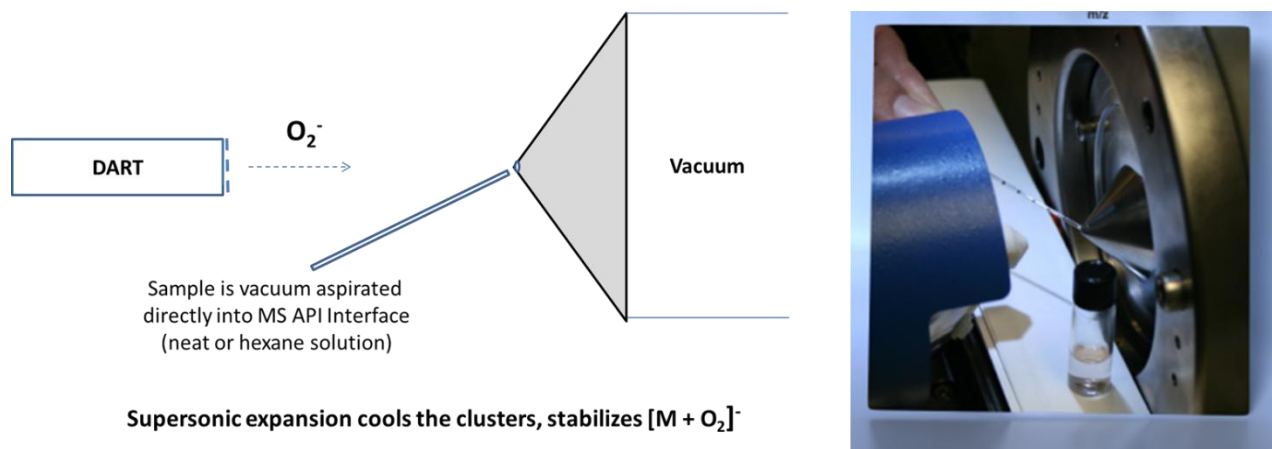
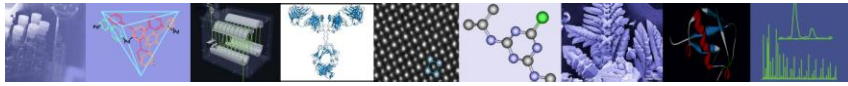


Figure 1. Schematic diagram and photograph of sample introduction for O_2^- attachment chemical ionization with the AccuTOF-DART.



Complementary information about polar additives and nonpolar base oil components

Figure 2. shows the positive-ion DART mass spectrum (top) of a synthetic motor oil and the negative-ion $O_2^{\bullet-}$ attachment chemical ionization mass spectrum (bottom) for the same oil sample. The positive-ion DART mass spectrum clearly shows the presence of polar dialkyldiphenylamine antioxidants and zinc dialkyldithiophosphate (ZDDP) anti-wear additives. The negative-ion $O_2^{\bullet-}$ attachment mass spectrum shows the large alkanes C_nH_{2n+2} and an abundant alkylnaphthalene that comprise the base oil.

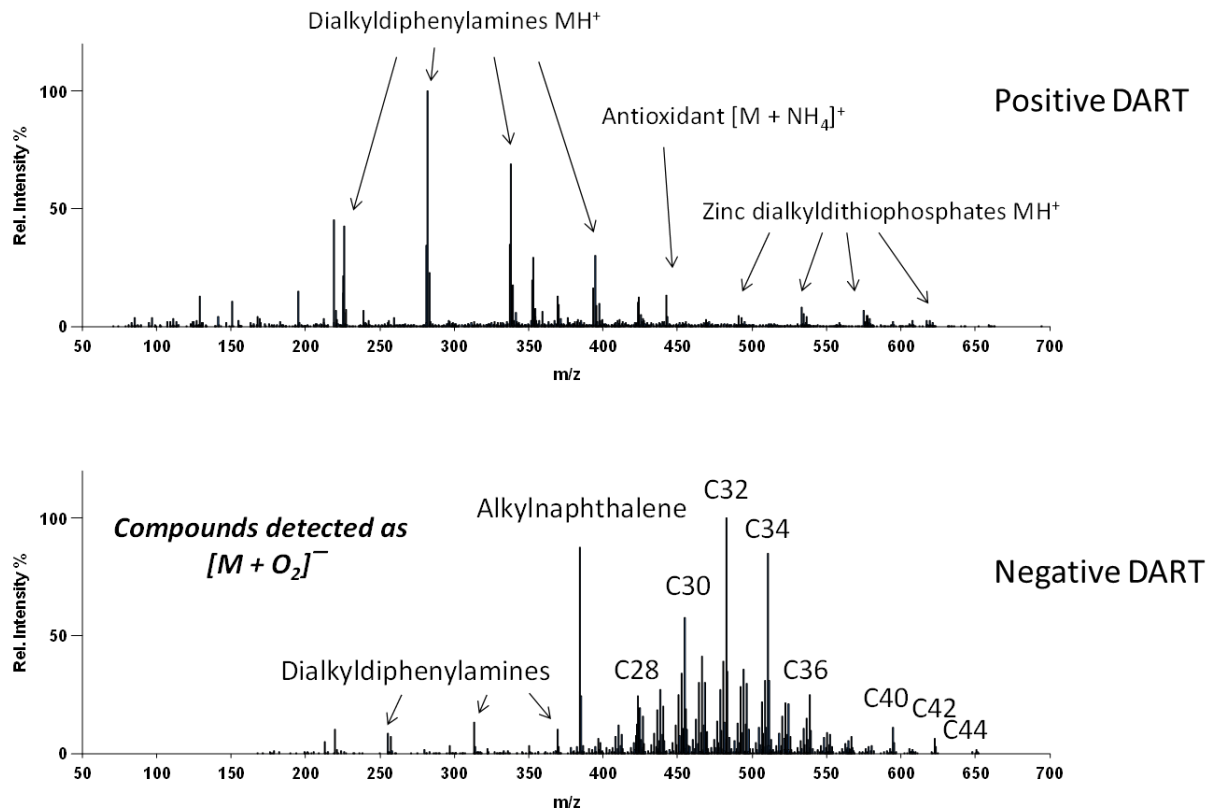
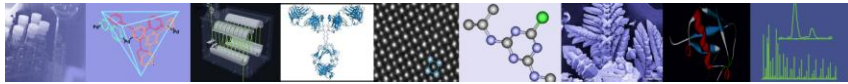


Figure 2. Positive-ion DART mass spectrum (top) showing the polar additives and negative-ion $O_2^{\bullet-}$ attachment mass spectrum (bottom) showing the nonpolar base oil components of a synthetic motor oil.



Comparison of the base oil composition of two different synthetic motor oils

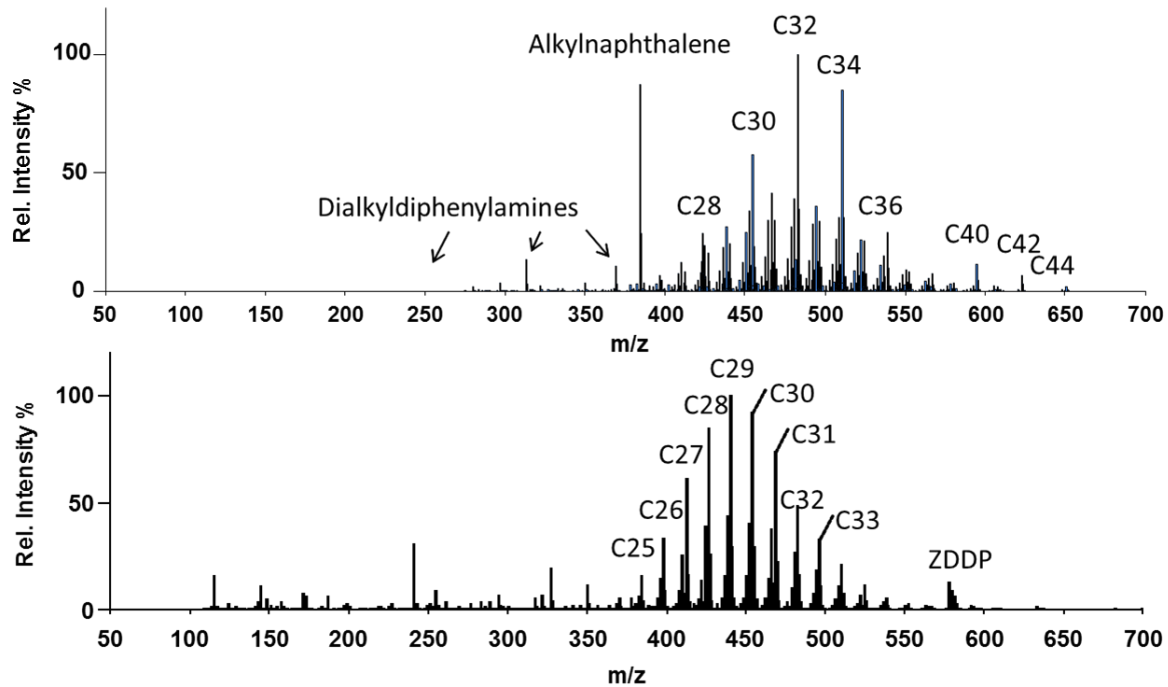


Figure 3. O_2^- attachment mass spectra showing differences in the base oil composition for two brands of synthetic motor oil.

Conclusion

The AccuTOF-DART can be used to rapidly identify additives in motor oils and also to characterize the base oil composition. The AccuTOF-DART offers complementary ambient ionization techniques that can be easily carried out without requiring any hardware changes.

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