Analysis of the influence of marine fuels on particle emissions from ships

U. Etzien[1], T. Streibel[2,4], N. Gierenz[1], T. Adam[3,4], B. Buchholz[1]*, R. Zimmermann[4]*

[1]Chair of Piston Machines and Internal Combustion Engines/ University of Rostock, [2]University of Rostock/ Division of Analytical and Technical Chemistry, [3]Universität der Bundeswehr München/ Institut für Chemie und Umwelttechnik , [4]Comprehensive Molecular Analytics (CMA), Helmholtz

In contrast to the extensive requirements for land-based particulate and fine dust emissions, the maritime sector is still in its infancy and has not yet been able to provide any global limit value regulations. It can be assumed that this topic will become more and more important in the future. With the last tightening of the IMO regulations on January 1st, 2020 (sulfur content in fuel ≤ 0.5% or use of an exhaust gas cleaning system outside of the ECAs), a change in the composition of the fleet emissions is to be expected. In this context, the joint project SAARUS was launched at the University of Rostock, with the aim to investigate ship-based emissions and to reduce them through optimized and expanded exhaust gas cleaning. In addition to reducing SOx emissions, the focus is on separating fine particles that measure smaller than 2.5 µm (PM2.5). In particular, the health-endangering fine dust fractions (aerosols) with particle diameters below 1 µm are only slightly reduced by conventional wet scrubbers. The approach to further decrease the particle load is therefore to use the scrubber as an optimized particle prefilter in order to create the boundary conditions for downstream filter technologies to be tested.

In this context, an extensive measurement campaign with six different fuels available on the market took place on a medium-speed single-cylinder research engine, which is representative of the maritime sector and located at the Chair for Piston Engines and Internal Combustion Engines. As part of the investigations, the fuel-based changes in emissions and the combustion behavior of a hydrogenated vegetable oil (HVO), a MGO, a limit-compliant HFO (sulfur content ≤ 0.5%), a standard HFO (sulfur content 2.4%) and two highly aromatic heavy fuel oils (sulfur content 0.06% and 1.3%) are analyzed. The following measurement methods were used to characterize the particle emissions: gravimetric filter analyzes, tapered element oscillating microbalance (TEOM), scanning mobility particle sizer (SMPS), Pegasor particle sensor, online single particle mass spectrometry (SPMS), filter sampling and two-dimensional gas chromatography / mass spectrometry (GCxGC-TOFMS), high-resolution mass spectrometry (HRMS for organic matter) and inductively coupled plasma / mass spectrometry (ICP-MS for elements).

The focus of the article is on the presentation of the most important findings of this measurement campaign. In addition to a comparison of the properties of the fuels examined, their effects on the particle load in terms of concentration, size distribution and chemical composition are discussed. In addition, the simulation approach for particle separation in the scrubber and the approaches for separating fine particles measuring smaller than 2.5 µm (PM2.5) as well as the harmful fine dust fractions (aerosols) with particle diameters below 1 µm are presented in an outlook.