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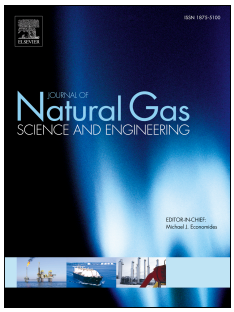

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Short communication

Particles in fuel-grade Liquefied Natural Gas

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The utilization of Liquefied Natural Gas (LNG) in the heavy-duty transport sector is a convenient and cost-effective step towards a sustainable future. However, there are questions regarding LNG fuel quality and destructive particles for engines. Basically nothing is known about particles in the commercial LNG being fueled today. The gravimetric and SEM-EDX results here demonstrates that there are precarious metal and silicon dioxide particles in fuel-grade LNG that can clog and erode engine parts. Considering these results further research in the direction of this study, including standardized method development, is highly motivated.

The incorporation of clean-fuel technologies has become essential for the sustainability of the transportation sector.(1, 2) Approximately one-quarter of the total greenhouse gas emissions in Europe can be attributed to the transport sector, with petroleum-derived fuels dominating road transport.(3) Natural gas is in many aspects considered as one of the most convenient and cost-effective ways towards sustainable fuels and transports.(4-6) With the substantial growth of the LNG (Liquid Natural Gas) fuels industry around the world, the opportunity to utilize LNG as a clean and low-cost vehicle fuel in heavy-duty vehicle applications is rapidly increasing.(1, 3, 7-9) Forecasts are that global LNG business will grow vastly over the next 20 years.(10) By a shift from conventional fossil fuels in heavy-duty transports to LNG the greenhouse gas emissions can be reduced by 20 %, while also producing much cleaner exhaust fumes and less noise.(3) Reduced NO_x emissions over diesel has been demonstrated for LNG.(9, 11) Recently natural gas, i.e. including LNG, has also been proposed as a potential link between existing distribution infrastructure and renewable energy sources.(8) The truck engines are based on different technologies which have different critical design criteria with regards to for example fuel composition and particle tolerance. Depending on the technology the engine is more or less sensitive to different fuel qualities or other specific parameters. Also, depending on the technology, solid particles such as SiO_2, could lead to premature wear due to erosion.(12) Therefore, the LNG should be delivered clean or be filtered at the refueling stations. Developing a standard method to quantify particles in LNG is necessary to achieve comparable results from all parties. The development of a method to quantify particles in LNG is also necessary in order to gather information of the fuel cleanliness, which in turn will support the development of a long-term onboard filtration solution and help define necessary filter maintenance intervals.

Since very little is known about particles in fuel-grade LNG, such studies are highly warranted due to the increasing use and potential damage and costs for long-term consumption of the LNG fuel. Here a gravimetric filter based method was developed and field-tested at a commercial refueling station in Gothenburg, Sweden. Particle amounts were quantified and further characterized by Scanning Electron Microscopy with Energy Dispersive X-ray spectroscopy (SEM-EDX), which generated both size and chemical information from the samplings. Previously, a sampling system was developed to acquire samples at LNG and LBG (Liquefied biogas) re-fueling stations.(13) The sampler were within this study further developed to collect particles mainly in the size range 0.5 – 60 µm for gravimetric determinations and further characterizations. Basic sampling system parts and design are illustrated in figure 1. See supplementary information for additional sampling system details and experimental methods.

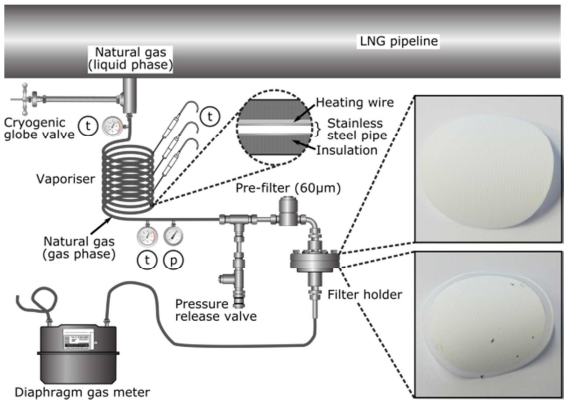

Fig. 1 Particle sampling section of the system. Incoming flow from the LNG pipeline is vaporized and passes through the pressure relief valve and through the 60 µm pre-filter, filter-holder with filter and the flow meter. Filter holder inset pictures shows a Teflon filter before and after sampling.