Experimental study on charging behavior of bio-fuels sprays generated by an annular electrostatic atomizer

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Abstract

An experimental study was performed to assess electrically insulating bio-fuels spray performance using an annular electrostatic nozzle. The bio-fuel oils used in this study were of differing viscosities, surface tensions and electrical conductivities. The spry characteristics were compared with ethanol spray, which is a semiconducting liquid. The spray pattern, breakup length and droplet specific charge were observed to be a function of liquid physical and electrical properties. The number of spray sites on the periphery of the annular nozzle was in good with the theoretical calculation. The droplet size, size distribution and charge to mass of the aerosols can be tailored to meet specific requirement by choosing proper applied potential and flow rate. The coverage of the sprays on the target surface was found to be high, but the uniformity needs to be improved.

Introduction

Today, in the world there is a continuous increase in oil demands while the natural reserves are depleting, and environmental problems are drawing more and more attention. Automotive industry and experts are actively pursuing research to come with new solutions to solve these problems. Many alternative solutions have been developed to replace oil consumption; unfortunately they still cannot offer the same efficiency, pushing the car industry towards developing new products and devices which are environmentally friendly and reducing car engine consumption. European Commission has agreed that a minimum of 10% of all petrol and diesel (calculated on the basis of energy content) for transportation purposes on markets shall be replaced by bio-fuels by the end of 2020 [1]. Electrostatic atomization has been attracting worldwide interest for over a century due to its inherent advantages over the atomization techniques. Electrostatic disruptive forces can be used to atomize bio-fuels at flow rates commensurate with practical combustion systems and that the charge injection technique is particularly suitable for highly resistive liquids [2]. Possible limitations requiring further research include the need to control the wide spray angle, which may provide fuel-air mixtures too lean near the nozzle, and the need to design for maximum charge injection rate, which is thought to be limited by corona breakdown in the gas near the nozzle orifice. Electrohydrodynamic concentric annular slit nozzle may be one of the methods of handling comparatively high flow rates compared with a single tubular nozzle, while still keeping the advantage of producing charged fine spray. Early work on the use of annular nozzle for generating ethanol electrospray was reported by Miao et al [3]. This paper reports the experimental study conducted to evaluate a single electrostatic annular nozzle for successfully spraying bio-fuels.

Materials and Methods

The experimental configuration is schematically shown in Figure 1. The system is composed of an annular slit nozzle with a diameter of 19mm. The slit is about 0.3mm wide. A ring electrode with a diameter of 58mm is made of a 3mm thick copper wire. This electrode is positioned 26mm above the nozzle edge. A grounded metalic plate or a cylinder was placed 150mm away from the nozzle. High voltages of a few kV to a few tens of kV were applied between the nozzle and the ring electrode which was also grounded. Three types of bio-fuels were fed to the nozzle the flow rates from 0.05ml/s to 1.5 ml/s. The spray process was imaged using a high DSLR shutter speed camera (Sony). Droplet size and size distribution of the spray was measured by a laser diffraction technique. The charge to mass ratio was obtained by measuring spray current using a Faraday pail.

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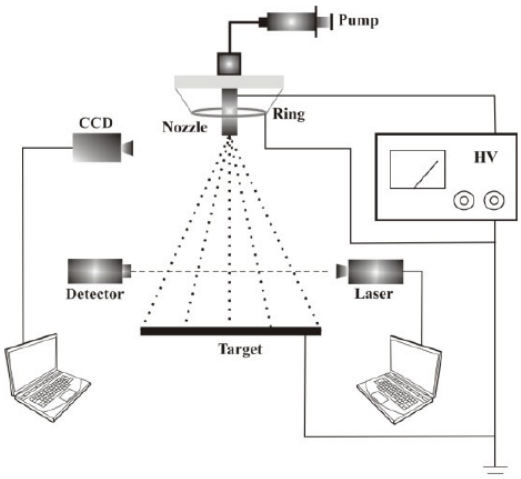

Figure 1. The schematic diagram of the experimental set-up

Results and Discussion

Figure 2 shows the influence of the applied potential on RME oil sprays generated by the annular nozzle.

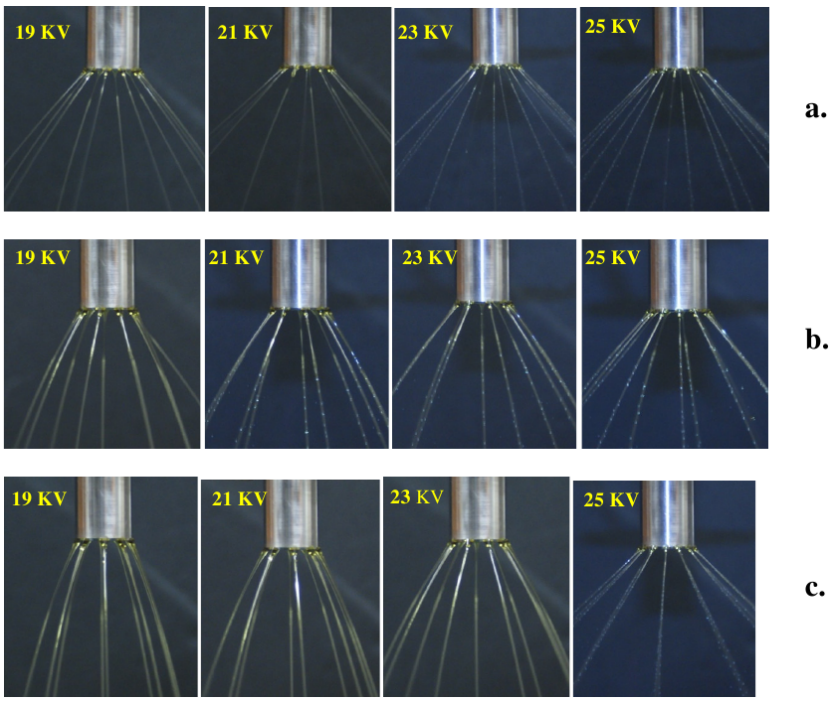

Figure 2. Shows the influence of the potential on spray. (a) 0.5 ml/s, (b) 1 ml/mis, (c) 1.5 ml/s.

Results presented were obtained using the nozzle in a vertical (facing downward) position. The coverage of the sprays on the target surface was observed using oil sensitive paper. The investigation on the angle of spray indicates that it may be possible to generate sprays at a horizontal nozzle position.

References

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