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Study of the influence of liquid properties on the aerosol emission by impact of millimetric droplets onto a liquid film

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The study of droplets impinging onto a liquid film is of both fundamental interest and practical importance to determine the potential sources of contamination in the case of scenarios of liquid falls such as dripping. The mains parameters keys of the impact phenomenon are the characteristics of the droplets (diameter d_i, velocity V_i, density ρ, viscosity μ and surface tension γ of the liquid) and the thickness h_{film} of the liquid film. The dimensionless numbers (Reynolds, Weber, Ohnesorge and the film parameter $S_f = h_{film}/d_i$) are used in order to characterize the phenomenon which can occur as the deposition, rebound and splash (Motzkus *et al.*, 2006). In previous study (Motzkus *et al.*, 2007), we have determined the influence of the parameters V_i and S_f on the emission of droplets in the splash regime and we have examined the relevance of existing relations on the deposition/splash threshold to estimate the presence or not of airborne particles. These results showed that for the water droplet the increase of V_i or the decrease of S_f involve an augmentation of the number of droplets emitted by impact in the range 2-50 µm. The objective of this work is to study experimentally the influence of the viscosity μ and the surface tension γ of the liquid on the emission of airborne particles during the impaction of droplets onto a liquid film.

The methods used to measure the emission of airborne particles (mass and size distribution) with a tracer (sodium fluorescein) and to observe the splash phenomena are detailed by Motzkus *et al.* (2006). We have measured the particles produced during the impact of droplets onto a liquid film, whose thickness is maintained constant, with a drip frequency of 0.4 droplet/s during 60 min, in a ventilated closed vessel. We have studied the influence of an increase of the viscosity and the decrease of the surface tension compared to these of the water (γ = 66 mN/m, μ = 1 mPa.s) respectively by using a mixture 50 % water/ethanol (γ = 28 mN/m, μ = 2 mPa.s) and a mixture 45 % water/55 % glycerol (μ = 9 mPa.s, γ = 66 mN/m). The water/ethanol droplets emitted with a diameter (d_e) smaller than 50 µm evaporate rapidly and give rise to dry airborne residues of tracer. In the case of the mixture water/glycerol, the residues are made up only of glycerol because the glycerol evaporates very slowly with respect to the water. The size distribution of residues is measured with an Aerodynamic Particle Sizer. The concentration of submicrometric particles is measured by a Condensation Nuclei Counter (CNC). The diameters of emitted droplets for the case of the mixture water/ethanol and water/glycerol are calculated from the residues diameters, respectively by using the concentration of the tracer (10 g/L) and the concentration of glycerol.

Figure 1 represents the count distributions of droplets produced by impact of a 4 mm-diameter droplet with V_i = 3.7 m.s^{-1}, S_f = 0.3 and different surface tensions and viscosities.

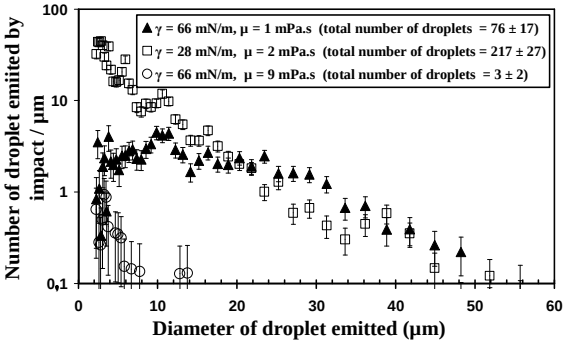

Figure 1. Count distributions of emitted droplets.

These results show that the increase of the viscosity by a factor 9 involves a strong decrease of the number of droplets emitted by impact in the range 2-50 µm. The decrease of surface tension by a factor 2, while keeping the viscosity nearly constant, involves a high production of droplets with sizes less than 15 µm. In the case of a low surface tension, the CNC measurements allowed to identify a production of submicrometric particles. The submicrometric particles emitted are due to the formation and the breaking of bubbles observed only in this case.

Motzkus, C., Gehin, E. and Gensdarmes, F. (2006) Study of aerosol production by normal impaction of millimetric droplets onto a liquid film. *Proceeding of the Seventh International Aerosol Conference*, 834-835.

Motzkus, C., Gehin, E. and Gensdarmes, F. (2007) Characterization of aerosol emitted by impact of millimetric droplets onto a liquid film. *European Aerosol Conference 2007*, Salzburg, Abstract T17A001.