SIGNATURE OF SALT-INDUCED DIFFUSION OF PARTICLES IN A TURBULENT WATER JET

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<u>*Abstract*</u>   We study particles dispersion in a turbulent water jet. We focus especially on salt-induced particle transport (diffusiophoresis). A coarse graining operation is used on scalar fields to quantify mixing scale evolution. Preliminary results show changes in the particle transport, characterized by an enhanced (or reduced) diffusion coefficient.

INTRODUCTION

The transport and mixing of molecules or particles are of practical importance in industrial applications or in nature (e.g. industrial chemical reactors, pollutant dispersion, sediment deposition). Mixing is obtained under the stretching and folding effects of turbulent structures and smoothing of scalar gradients is achieved thanks to molecular diffusion. Surprisingly, its role on the overall mixing properties and efficiency is often overlooked, although signature of its influence has been reported in turbulent mixing [4]. In this respect, it is of particular interest to consider a new phenomenon explored by Abécassis *et al.* [1] that strongly affects the transport properties of particles. A gradient of molecular solute (salt, polymer, etc.) is responsible for nano-scale flows at a particle interface. This phenomenon, known as diffusiophoresis, results in tremendous changes in the particle dynamics, characterized by a diffusion coefficient enhanced (or reduced) by orders of magnitude. As such, the diffusiophoresis phenomena can be of significant relevance for particle mixing.

EXPERIMENTAL SETUP

In order to highlight the potential role of diffusiophoresis in turbulent mixing, a turbulent water jet apparatus is designed. This configuration is chosen because it is fairly well known and documented [2]. Schmidt effects are first investigated using 3 different substances with known diffusivity coefficient (rhodamine B, dextran and colloids labeled with fluorescent dye rhodamine B).

The experimental setup consists of a parallelepiped PMMA vessel. The turbulent round water jet is induced thanks to an injector at the bottom center ($300 \leq Re \leq 3{,}000$ based on the injector diameter). The fluorescent dye and the large particles (dextrans and colloids) labeled with fluorescent dye is injected at a location where the jet flow is fully developed and self-similar (Figure 1). The flow is visualized and quantitatively characterized with PLIF and PIV.

PRELIMINARY RESULTS

According to Villermaux and Duplat [4] who studied the mixing of a single scalar in a turbulent field, increasing the Schmidt number Sc tends to decrease the mixing length. Here, a coarse graining method [4] is used in order to obtain a mixing length of concentration fields of large particles, noted η. The preliminary results [3] show that η approximately scales (Figure 2a):

$$\eta = \frac{A\,(Sc)}{Q} \tag{1}$$

where A is a variable function of Schmidt number and Q the flow rate. In the case of particles+salt (LiCl) mixture, the mixing length η is lower for dextran and colloids corresponding to a Schmidt number Sc greater by 2 orders of magnitude against their original Schmidt number. The Schmidt number Sc is deduced from the Figure 2b. On the opposite, the injection of particles in a solution of water and LiCl (not shown here) seems to enhance diffusivity.

The preliminary results highlight the role of a nano-scale mechanism for a macro-scale mixing. Current and future work will complete these first investigations via an experimental setup able to obtain concentration-velocity correlations.
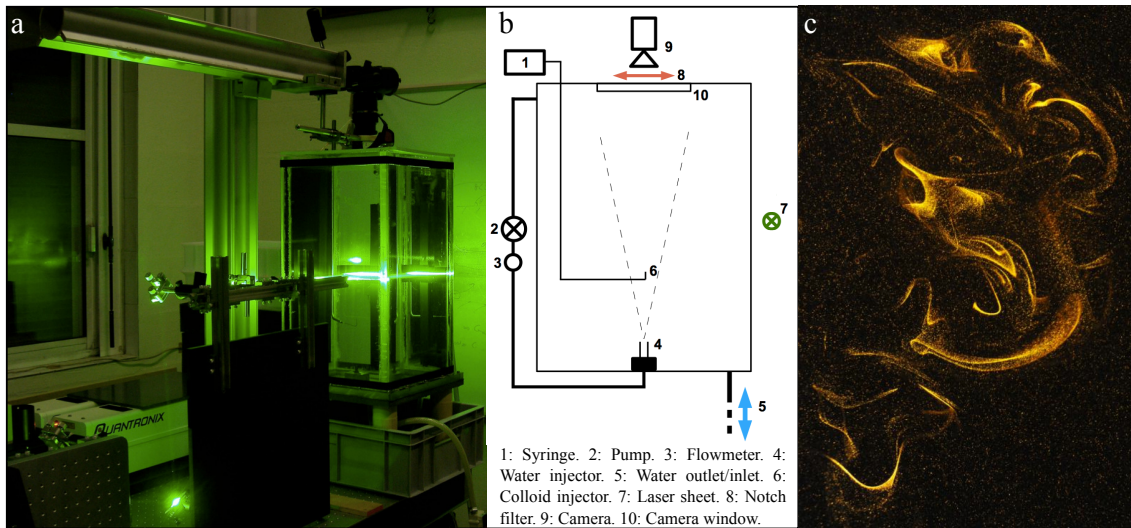
Figure 1. a: Experimental setup. b: Sketch of the experimental setup. c: Example of colloid injection in the water jet [3].
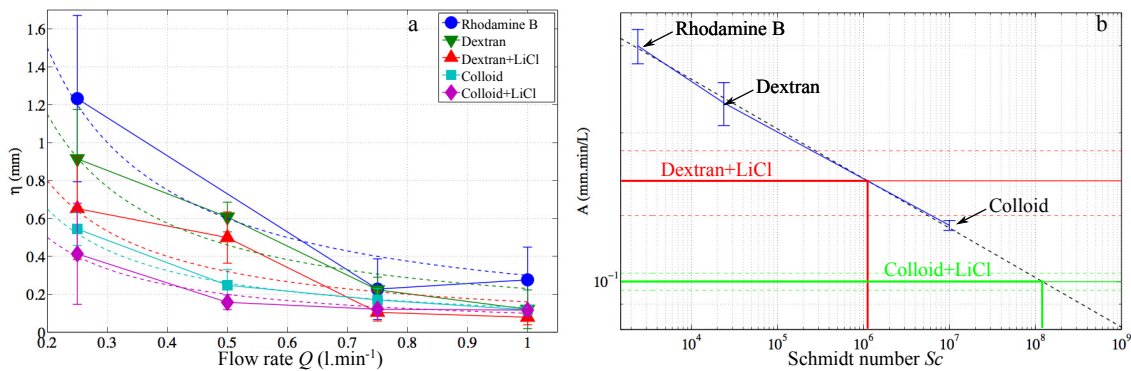

Figure 2. Preliminary results. a: Evolution of mixing length η versus flow rate Q. b: Evolution of variable $A\,(Sc)$ versus Schmidt number Sc. [3]

References

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