# MicroMAP: A Material Acceleration Platform for the Synthesis of Organic Nanoparticle Dispersions

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## 1. Introduction

The increasing appreciation of sustainability and the restriction of hazardous substances (RoHS) has fostered many innovations of eco-friendly production processes in industry. In particular, coating processes have undergone major transformations from toxic and/or carcinogenic to less harmful media. Prominent examples include the development of water-based car finish or dispersant wall paints. Nowadays, the use of eco-friendly agents in coating processes is often industry standard.

Recently, the quest for eco-friendly processing routes has been extended to the fabrication of organic optoelectronic devices which increasingly gain commercial relevance: nanoparticle dispersions of organic semiconductors in alcohols or water are being developed, replacing toxic aromatic solutions. [1,2] The synthesis of organic semiconductor dispersions by nanoprecipitation is a complex parameter space, including the choice of solvents, non-solvents, semiconductor mixtures and stabilizing agents which is hardly manageable by manual batch-to-batch experiments.

In this work, we present a microfluidic materials acceleration platform (MicroMAP) which enables the fast screening of synthesis parameters towards tailored and stable organic semiconductor dispersions.

## 2. MicroMAP

The MicroMAP (Figure 1) features eight parallel syringe pumps. Differential pumping speeds enable the screening of mixing ratios of semiconductors, semiconductor concentrations, stabilizer concentrations and solvent ratios, all at the same time. The compounds flow through a microfluidic chip with vortices for best mixing and most reproducible dispersion synthesis. [3] The dispersions are then automatically collected in an array of vials which are moved with a gantry throughout the experimental setup. The rotary gripper of the gantry has also been designed to open and close vials to avoid evaporation of the solvents and hence corruption of the experimental results. The properties of the dispersions are monitored inside the vials by automated, pneumatic dynamic light scattering probes (i.e. to determine the nanoparticle size) and by UV-Vis absorption measurement probes, altogether producing a comprehensive picture of the formation of nanoparticles and their colloidal stability.

Fig. 1: MicroMAP setup. Front left: syringe pump array. Background: gantry for the handling of vials. In between: Probe stations for dynamic light scattering and UV-Vis absorption probes.

## 3. Scientific Results

A core challenge for the automated synthesis of dispersions by microfluidics is the precise control of fluid dynamics. In order to prevent the backflow of components into other syringe pumps and channel clogging, we have optimized microfluidic chip geometries. [4]

The system reliably synthesized a set of nanoparticle dispersions in alcohol which were then used to produce organic semiconductor devices, in particular organic solar cells.

While organic semiconductor dispersions were the primary objective for the development of the MicroMAP, its applicability goes far beyond. In the future, it can be used to automatically synthesise, mix or condition any dispersions or solutions and thus will be of interest for the broader coating community.

For this purpose, future work will be oriented towards the incorporation of the MicroMAP into

a larger automated coating system, spanning from the ink synthesis to layer deposition and characterization – and eventually the automated fabrication of organic optoelectronic devices.

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