Designing Aqueous TiO$_2$ Suspensions for the Use in Ink-Jet Printing Technology

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Ink-jet printing which is traditionally used in graphical industry has recently found its use in the field of material science for producing active and passive 2D and 3D structures of functional materials on various substrates. Practically any material can be used for printing from inorganic, organic, polymer to biological substances, therefore the method can be used in a wide range of applications such as: organic thin film transistors, light-emitting diodes, solar cells, conductive structures, memory devices, sensors, and biological/pharmaceutical applications. The main advantages of this method are that it is cost effective, it does not need post-processing such as etching therefore it reduces waste, and the design of patterns is digital, therefore no templates for shaping are needed.

The main challenge in the field of ink-jet printing of materials is to prepare printable inks containing functional materials that would enable reproducible results. The ink for printing has to be in the liquid form; therefore functional material can be either dissolved or dispersed in an appropriate fluid. Our research is focused on preparation of stable colloidal suspensions containing inorganic particles suitable for ink-jet printing. The main requirements regarding the quality ink preparation are its fluid properties such as viscosity, surface tension, and density, colloidal stability, and size of the particles in the ink. Clogging of the nozzle can be avoided if the particles are about 50 times smaller than the nozzle diameter, and should be in general smaller than 500 nm.

In this work we are presenting the preparation of environmental friendly aqueous TiO$_2$ suspensions and its patterning with an ink-jet printer. First the size reduction of TiO$_2$ particles to the sizes below 400 nm was achieved with the use of colloidal milling. The particles were electrostatically stabilized adjusting the suspension pH. Then the surfactants were added to control the surface tension, while glycerol was used to control the viscosity and drying of the ink. All the parameters were optimized to ensure quality drop formation in the printer, which is crucial to increase quality and reproducibility of the printed structures. Printable suspensions containing TiO$_2$ nanoparticles were prepared. Furthermore patterns of TiO$_2$ particles were successfully printed on the substrate with the good accuracy and reproducibility, see Figure 1.

![Pattern of printed dots of TiO$_2$ nanoparticles on SiO$_x$/Si substrate. The single dot has a diameter of 40 μm.](image-url)