Reduction in friction in pipe of high-viscosity ink by ultrafine bubbles

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The inkjet printing technology is expected to contribute to global carbon neutrality in various industries, including the automotive industry, because of its coating efficiency of 100%. This is a technology that is expected to develop in the future. However, it has not yet been widely employed in practice. One of the reasons is that the flow piping of the head used in inkjet printing is narrow and intricate, which results in high-pressure resistance, making it difficult to stably dispense a high-viscosity ink. To overcome this problem, we propose friction reduction in the pipe using ultrafine bubbles (UFBs). UFBs are invisible bubbles with diameters smaller than 1 µm, which remain in the liquid for a long time, are negatively charged, produce hydroxyl radicals upon collapse, and adhere easily to walls and grooves. These properties of UFBs provide various benefits such as cleaning, sterilization, lubrication, and physiologically active effects. Prior study includes research on the reductions in friction and fuel consumption by producing UFBs in automobile engine oil and research on reduction in grinding resistance by producing UFBs in coolant during the grinding process. We aim to utilize these characteristics of UFBs in inkjet printing to reduce the friction between the high-viscosity ink and piping, and thereby improve the discharge stability. To quantitatively confirm that UFBs reduce the friction between the ink and piping, we measured the flow rates of the ink circulating in a channel with and without UFBs and compared the results. A UFB-generation device and flow meter were installed in the flow channel, and three types of ink settings were employed. In the first, the ink was circulated while generating UFBs (UFB-generation). In the second, the ink was circulated without generating UFBs (Unit). In the third, the UFB-generation device was replaced by a tube, and the ink was circulated (Tube). The flow rate was measured in 15-min increments up to 60 min, and the data were compared. The types listed in descending order of the flow rate at 60 min are UFB-generation, Tube, and Unit. The flow rate of the ink containing UFBs was higher than that of the ink without UFBs. The flow rate of the UFB-generation ink increased with time, while those of Tube and Unit ink remained constant. These results indicate that the flow path equipped with the UFB generator is more difficult for the ink to flow than the tube-only flow path. This effect is counteracted by generating UFBs for certain time, and the flow rate becomes higher than that of the tube-only flow path by providing more time on generation of UFBs. This indicates that UFBs reduce the friction in the tube and smooth the flow of the high-viscosity ink. The number of UFBs in the ink increases with time, and the friction-reducing effect is expected to become more pronounced.

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