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RESEARCH ARTICLE

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Method for determining mixing index in microfluidics by RGB color model

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Abstract

Microfluidic mixing is a key process in miniaturized analysis system. Achieving adequate mixing performance is considerably difficult in microfluidic micromixer, as the flow is always associated with unfavorable laminar flow and dominated by molecular diffusion. The mixing performance of these micromixers are generally characterized as a function of mixing index based on dispersion (homogeneity) information, leading to either an overestimated or underestimated mixing index. This paper presents a new method for determining the mixing index of micromixers based on RGB color model by decoding mixing images to their respective red, green, and blue pixel intensities. Several digital composite images were used to perform initial benchmarking, and the proposed method accurately quantified the mixing index significantly better than previously adopted methods. The practicality of the method was further demonstrated by characterizing mixing of well-known micromixers, namely T- and Y- micromixers, at varying Reynolds numbers of $5 \leq Re \leq 100$. The results show that the mixing index decreases with the increase in Reynolds number, whereas the mixing index of the T-micromixer was superior to that of Y-micromixer, both agreeing well with the literature. The mixing index of these micromixers at varying Reynolds numbers of $5 \leq Re \leq 100$ calculated using other methods were also compared and discussed. The proposed method is foreseen handy and robust in characterizing mixing in real time for gradient mixing in networked microchannels and multivortex mixing for the manipulation of fluids, particles, and biological substances.

KEYWORDS
microfluidic, micromixer, mixing index, mixing performance, RGB model

1 | INTRODUCTION

Microfluidics has extremely widespread applications ranging from drug development, chemical and biomedical analysis, and food processing to pharmaceuticals and pathogen detection.[1,2] In particular, microfluidic micromixers play crucial roles to enhance mixing of dissimilar fluid properties that can be driven either actively or passively.[3] Obtaining adequate mixing performance is desirable but considerably difficult, because the Reynolds number in the microfluidics typically falls into a laminar regime, and the mixing rate is dominated by molecular diffusion.[4] The mixing performance of these micromixers is generally characterized as a function of mixing index. On the basis of color changes, the mixing index has been employed to characterize mixing between dye colored