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Chapter 1

This is an introductory chapter. A brief description on recent developments in the field of micro-reactor technology is provided. Important parameters characterizing helical structures are discussed and overview on the development of coiled flow inverters (CFIs) is presented.

Chapter 2

In this chapter, the new micro-structure i.e. AFIs, their designs, innovative points, and the advantages they bring compared to helical coils and CFIs are discussed. A detailed comparison between AFIs and CFIs is based on space design diagram is presented. The chapter describes also the fabrication of the new structures by using photopolymer inkjet 3D printing.

Chapter 3

This chapter covers different characterization aspects performed numerically and experimentally to understand the flow behavior and the mixing performance of the newly suggested designs.
For hydrodynamics, pressure drop was determined experimentally and numerically. CFD simulations were conducted in the laminar flow regime to understand the flow behavior inside AFIs at low Reynolds number. Mixing, a study on residence time distribution was performed numerically to compare the effect that AFIs have on axial dispersion in comparison to CFI structure. Furthermore, micromixing time was determined experimentally via the Dushman-Villermaux reaction and the incorporation model.

Chapter 4

This chapter describes a new modeling approach implemented to assess multiphase flows in helical structures. The new model is implemented by modifying the momentum conservation equation to accommodate geometry simplification. The effect of hydrodynamics on mass transfer in the slug was studied in the case of oxygen diffusion into water. Assessment of mass transfer enhancement was performed qualitatively and quantitatively. The work concludes that there is no substantial enhancement of mass transfer in CFIs in comparison to coils in non-reactive systems.

Chapter 5

In this chapter a summary of the main conclusions along outlooks and further directions to this research are presented. The advantages brought by the new AFI structures can be further investigated in various applications such as heat transfer, photochemical reactions, and multiphase flows.