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Hydrodynamic Stability in Bubble Columns: Impact on Reactor Scale-Up

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Highlights

- Bubble column reactor geometry selection determines complex internal circulation patterns
- Coupling of reaction and hydrodynamics drives optimal reactor configuration selection

1. Introduction

Gas-liquid reactors remain an important class of commercial reactors for numerous process chemistries ranging from biological fermentation to olefin hydroformylation. Effective reactor scale-up relies on a definitive understanding of the commercial-scale reactor hydrodynamics and interplay between reaction kinetics and hydrodynamics. The complex behavior of buoyancy-driven gas-liquid flows in bubble column reactors is often represented simply as plug flow or mixed flow for commercial scale-up purposes; this representation overlooks potential performance debits or scale-up risks omitted through oversimplification. This work treats the importance of considering the dynamic complexity of reactor circulation patterns in reactor scale-up as it will influence decisions on reactor configuration and design.

2. Methods

We present a framework to study bubble column reactor hydrodynamics using stability analysis, dynamic phenomenological modeling, and computational fluid dynamics. These models are tools to scope reactor performance *a priori* to aid in selecting reactor configurations appropriate for particular chemical processes. Often these models have been used in isolation [1-4], but are more powerful in conjuction. Each of these models possess complementary benefits and limits, and in many circumstances experimental testing is required to evaluate hydrodynamic uncertainties.

3. Results and discussion

The presentation will discuss the impacts of reactor geometry and operation on its hydrodynamic complexity and stability; the effects of column aspect ratio, baffles, gas distribution, and flow regime are evaluated among potential commercial reactor design options. The results show how specific reactor configurations are preferred for robust reactor scale-up and even small design details may have a significant impact on large-scale performance. Experimental data is presented that validates these predictions in specific cases.

4. Conclusions

Reactor scale-up in bubble column reactors is discussed in the context of reactor circulation and hydrodynamic stability. This work presents an integrated framework to explore these scale-up concerns and evaluate their impact on reactor configuration selection, scale-up and design. This approach is a valuable tool for early reactor scoping in potential chemical process applications.

References

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Keywords
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