

Reaction-Based Fluorescent Mixing Diagnostics

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The flowers that bloom in the Spring...

- Predictions of results are less accurate than reports of results. Hence,
- This presentation will address
 - A colorimetric FOB (formation of byproduct) system
 - An attempt to generate a simple reaction-based simultaneous PLIF/PIV system
 - New ideas -- Can we image the reaction rate?

The three-legged stool

- How can we make a real difference in predicting the performance of industrial mixing processes?
We will need
 - the right CFD approach
 - the right set of flows in the experiment
 - the right set of diagnostics for the experiment
- We must decide what is most valuable to measure and design a diagnostic to get that information!

The right fluorescent diagnostics....

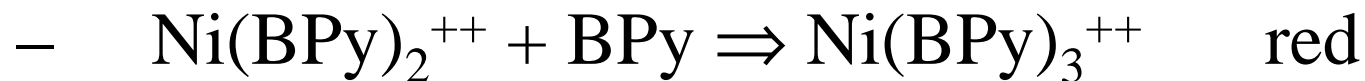
- are always reaction based,
 - Dilution diagnostics always have the ambiguity that results from inadequate spatial resolution.
- allow quantitative, spatially and temporally resolved measurement of the
 - velocity field (PIV)
 - reactant field
 - intended product field
 - byproduct field,
- and/or ... (to be filled in by attendees)

Colorimetric FOB

- Model reaction



- FOB system



Colorimetric FOB

Ratio of Ni : 2,2' Dipyridyl
H₂O EtOH



Colorimetric FOB

- Demonstration experiment
 - Beaker contains two moles of BPy per mole of Ni^{++}
 - Solutions are stratified initially
 - Mixing is driven by air bubbles
- Colors
 - Green and clear solutions are “unmixed”
 - Purple is 1:2 (desired product)
 - Red is 1:3 (byproduct)

Colorimetric FOB



BPy solution on top of Ni^{++} solution, no mixing

Colorimetric FOB



Mixing (driven by air bubbles, which are not shown)

Colorimetric FOB



Mixing is almost complete

Acronyms

- PLIF -- planar laser induced fluorescence
- DPLIF -- planar laser induced fluorescence, with a dilution diagnostic (rhodamine B)
- RPLIF -- planar laser induced fluorescence with a reaction-based diagnostic
 - turn on or turn off -- RPLIF with a single transition (fluorescein in acid/base system, rhodamine WT) = 1RPLIF
 - turn on and turn off -- RPLIF with double transition (off to on to off) = 2RPLIF

Simultaneous PLIF/PIV

- Rhodamine WT absorbs strongly at 532 nm and fluoresces well away from 532 nm
- Hence, can do simultaneous DPLIF/PIV
- Rhodamine WT is non-toxic
- Can we couple Rhodamine WT fluorescence to a reaction and do simultaneous RPLIF/PIV?

1RPLIF/PIV

- Fe^{+++} quenches Rhodamine WT fluorescence strongly
- $\text{Fe}(\text{EDTA})^+$ is a weak quencher.
- $\text{Fe}^{+++} + \text{EDTA}^- = \text{Fe}(\text{EDTA})^+$
- It almost worked.

2RPLIF

- The fluorescence occurs only in the reaction zone
- If the reactants and rate constants are chosen properly, then the intensity in a 2RPLIF experiment is directly proportional to the reaction rate.
- System is in the early stages of development.

2RPLIF

preliminary results

- $A + B \Rightarrow C$
- $C + B \Rightarrow D$
- A, B, and D are not fluorescent; C can be excited with near UV light, and C* fluoresces.

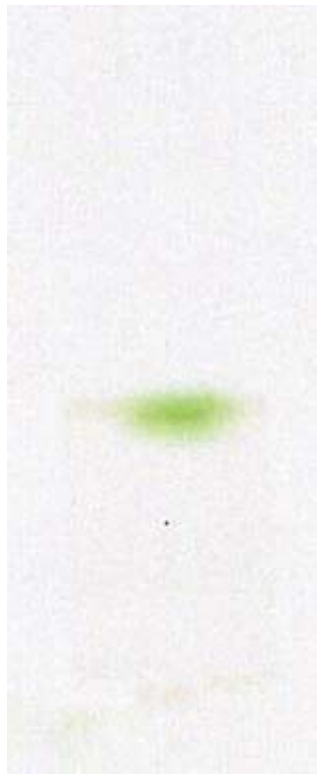
2RPLIF

preliminary results

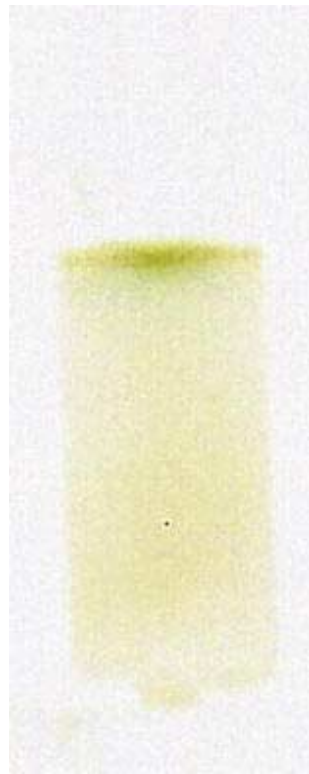
- Experiment:
 - use DVD camera to record experiment
 - place test tube of A on “black light”
 - squirt approximately equal volume of B into A
 - capture image, crop, and create false color image for presentation

2RPLIF

preliminary results



$t = 0$ sec



$t = 1$ sec



$t = 2$ sec

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