MOF Nanoparticle synthesis via Microfluidics: Dean flow impact on particle size

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Mixer

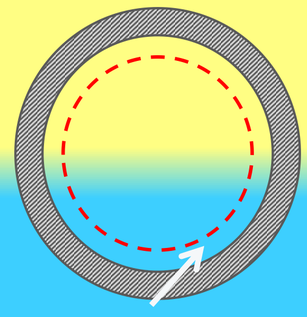
$Zn(NO_3)_2 + 2Hmim \rightarrow ZIF\text{-}8 + 2HNO_3$ in MeOH

Experimental parameters
- ZIF-8
- M:L:MeOH: 1:2:750
- Room temperature
- Aging time 0.5 h
- 1.5 m of PTFE tube.
- ID=0.750 mm

Laminar flow

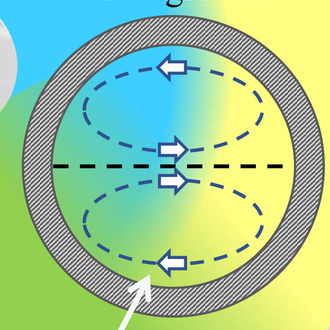
Poor mixing: long nucleation & slow growth

The tube cross-section



The stagnant circle

Dean flow
Good mixing: fast nucleation & fast growth

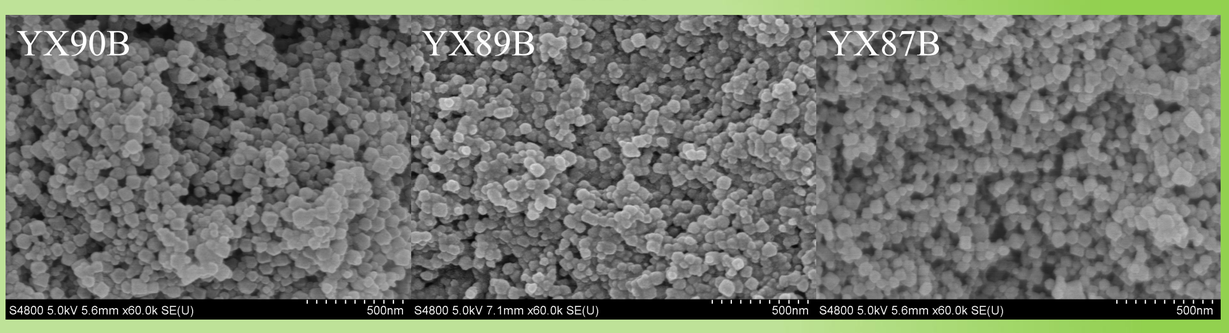


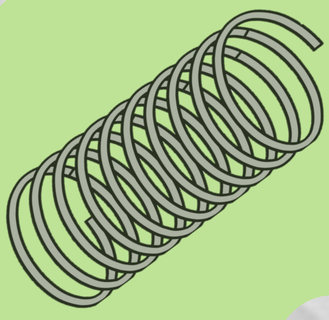
The dean vortices

Straight tube:
- Curvature radius: ∞

Flow rate(ml/min)

3.150 2.280 1.757



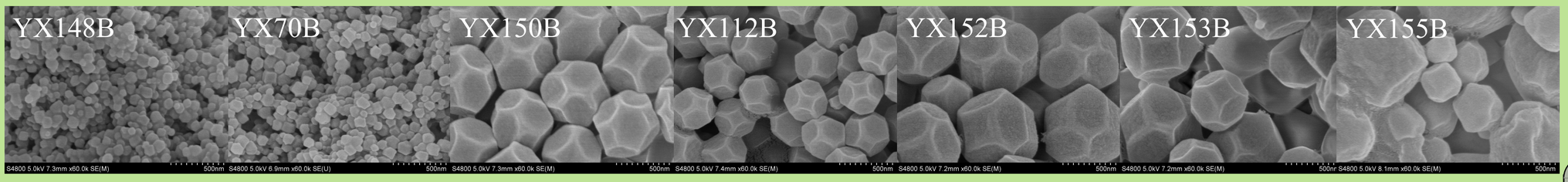


Coiled tube:
- Curvature radius: 4.794 mm

The straight tube presents smaller particles of lower quality, less influenced by the concentration and the flowrate.

Dean number

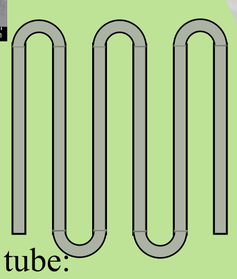
20 40 50 60 80 100 150



0.879 1.757 2.196 2.635 3.513 4.391 6.590

Flow rate (ml/min)

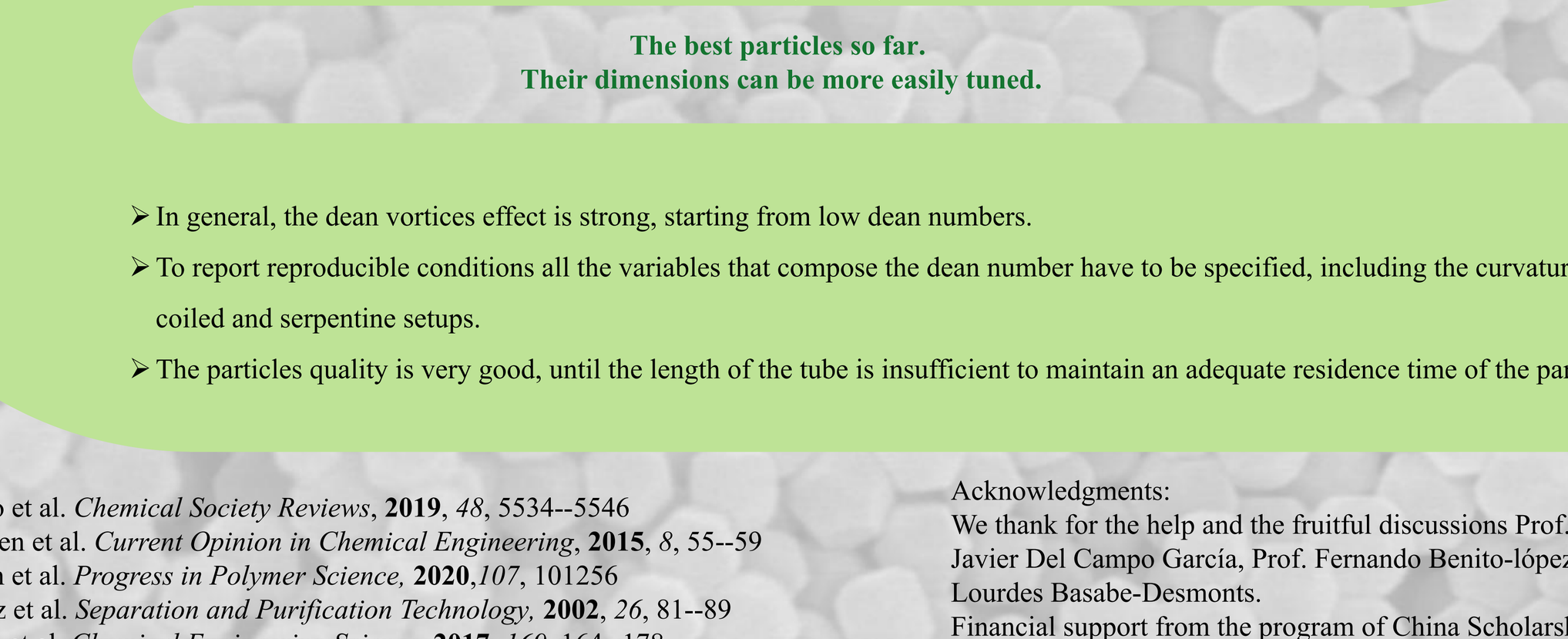
The flow rate is not sufficient to completely describe the reaction and to make it reproducible.
The dean number have to be specified, including the curvature radius.



Serpentine tube:
- 11x180° bends
- Curvature radius: 4.794 mm

Dean number

20 40 50 60 80 100 150



0.879 1.757 2.196 2.635 3.513 4.391 6.590

Flow rate(ml/min)

The best particles so far.
Their dimensions can be more easily tuned.

- In general, the dean vortices effect is strong, starting from low dean numbers.
- To report reproducible conditions all the variables that compose the dean number have to be specified, including the curvature radius for coiled and serpentine setups.
- The particles quality is very good, until the length of the tube is insufficient to maintain an adequate residence time of the particles.

References:
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