BY: Infinity Supercritical Staff EG TAGS: Supercritical CO2 Oil Extraction, Cannabis, Oil Concentrates

Synthesis of TiO 2 nanoparticles in a spinning disc reactor

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Technology Review of Spinning Disc Reacor | Blog | Industry Series | July 2017 7/27/2017

Review: Mohammadi, S., Harvey, A., & Boodhoo, K. V. (2014). Synthesis of TiO 2 nanoparticles in a spinning disc reactor. Chemical Engineering Journal, 258, 171-184.

A spinning disc reactor (SDR) is a reactor where reactants are injected onto the surface of a rotating disc, which creates a centrifugal force pushing the liquid out to the ends of the reactor where it exits at the bottom of the reactor.

The pros of such a reactor are that: the disc and walls can be temperature controlled, additional pipes can inject catalysts (particles in a slurry, or as a gas), pressure can be controlled, it is continuous flow, and that the disc creates a very interesting dynamic on the reaction, all allowing for a high level of process control and thus selectivity in the reaction.

It has been shown that SDR's can be used to make quantum dots, or semiconductor nanoparticles. This paper summary of the precipitation synthesis of titanium oxide (TiO_2) nanoparticles with an SDR will highlight some of the advantages to using an SDR for this purpose.

Nanoparticle TiO2 has many uses from being used as a pigment or catalyst, to being used in pharmaceutical products or surface coatings.

Traditionally it is made uses a sulphate or chloride process, both considered very toxic for the environment due to their waste products, but can be made through a synthetic route with adequate process control.
SDRs have been focused on recently due to their quote ability to provide a uniform and rapid micromixing environment when two liquid streams are contacted on the rotating surface unquote.

Micromixing relates to when two liquids are contacted on the disc and the extreme centrifugal force creates a thin-film region of intense heat and mass transfer.
In nanoparticle precipitation processes, micromixing is incredibly important because it allows for control of the supersaturation of the medium, a key parameter in the nucleation process.
Micromixing also gives control of the molecular diffusion which is a key parameter in the growth process of the crystals.
SDRs also create near ideal plug flow conditions which helps produce quote much more well defined crystals unquote.

Finally, the operating costs of an SDR are usually much less than the operating costs of similarly continuously mixed reactors.
The production of these TiO2 nanoparticles follow two simultaneous reactions, first the hydrolysis of titanium tetra isopropoxide (TTIP) with acidic water and then the polycondensation of the resulting titanium tetrahydroxide using nitric acid as a catalyst.

Four different factors were considered in this experiment, the rotational speed of the disc, the total flow rate, the grooved nature of the disc, and the ratio of water to precursor.

First, the rotational speed of the disc from 400rpm to 1200rpm produce vast differences in both particle size, where 400rpms producing an average particle size of ~16nm while 1200rpms created an average size of ~4.8nm, and particle size distribution, where 400rpms produced a range of particle sizes of 18nm and 1200rpms produced a range of particle sizes of 3nm.

This result was found to be due to the micromixing effect causing a high uniform distribution of supersaturation in the higher rpms.

Second, at higher flow rates smaller sized particles and more uniform sizing distribution were found due to a similar effect to the higher rotational speed, where a higher flow rate causes more surface ripples, meaning better mixing of the precursors and thus a favoring of nucleation vs crystal growth.

Third, this effect was again seen with the grooved disc preforming vastly better than the smooth disc in producing smaller and more uniformly sized particles.

Finally, a higher ratio of water to the precursor TTIP produced more uniform, smaller, and spherical in nature particles compared to less uniform, larger, and irregular particles with lower ratios.

This effect is due to the nucleation reaction being increased with higher water concentrations due to its large role in the hydrolysis reaction.

Comparing the SDR to more traditionally stirred reactors, the power consumption per particle was lower, the particle size was lower, and the particle size distribution was tighter in the SDR.

In conclusion, a SDR has many advantages over conventionally stirred reactors in the production of TiO2 nanoparticles and these advantages could possibly be applied to the production of other quantum dot particles.

Source:

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