Evaluation of Spinning Disk Reactor Technology for the Manufacture of Pharmaceuticals

1) This article describes a set of experiments that were performed to investigate the viability of implementing a Spinning Disk Reactor (SDR) to speed the production of pharmaceutical constituents.
2) It has been suggested that the SDR offers distinct advantages over the traditional Stirred Tank method of processing technology which is quote – simply scaled-up versions of the beaker in which the process was originally devised – unquote.
3) One downside of the Stirred Tank methodology is that the surface-to-volume ratio decreases as the system is scaled up. This induces inefficiencies that are not present in the beaker-scale process these systems are designed around. The largescale vessels may inhibit the naturally fast reaction times inherent in the composition.
4) For SDR viable reactions, quote – fluid residence times...are in the range of 1-5s compared with a few hours in a stirred vessel – unquote, offering the potential for significant process time reduction.
5) The greater mixing intensity offered by the SDR also has the potential to improve reactant concentration profiles as well as yield better product particle size selectivity.
6) An SDR in its basic sense is a horizontal rotating disk. The reactants in a desired chemical reaction are poured into a small well in the center of the top side of the disk. Forces created by the spinning nature of the disk move the reactants outwards in a thin film towards the perimeter of the disk, inducing significant shear forces along the way. These shear forces are what is primarily responsible for the great mixing intensity offered by the SDR.
7) SDR architecture also allows for precise temperature control. The housing walls can be heated or cooled along with the disk. The disk has fluid channels machined in which direct heat transfer fluid from the periphery of the disk towards the center and back out the shaft.
8) This heat transfer fluid path creates a counter current flow with regard to the thin film of reactants offering highly efficient and selectable temperature environment.
9) The trial investigated 6 types of reactions: (1) phase-transfer Darzen's process (2) crystallization study (3) Knoevenagel reaction (4) condensation process (5) elimination reaction (6) exothermic condensation.
10) Due to the short residence times of 1-5 seconds, reaction types (3)-(5) were found to be not viable using the SDR. These reaction types, quote – displayed low conversions in the range of 0 percent to 10 percent – unquote, due to their low intrinsic reaction speed.
11) Reaction type (6) was found to be non-viable due to product selectivity which was, quote – significantly lower than that in the batch process – unquote.
12) Reaction types (1) and (2) were used to further investigate the impact of disk rotational speed, disk texture, and process temperatures on overall process efficiency.
13) While attempting to test different process temperatures it was necessary to use a heat transfer fluid other than water to achieve sub zero C cooling. In this case, Therminol 59 and Dowcal 10 were tested as possible options.
14) Heat transfer fluid testing indicated that not only the fluid, but also the disk material itself (316 SS or Naval Brass) had a significant impact on the heat transfer capability of the system.
15) This article concludes that SDR technology is viable and advantageous for certain chemical reaction processes.
16) Reactions quote – with species half-lives up to 5s, can be performed much more effectively in an SDR than in a stirred vessel – unquote, with up to a 99.9% reduction in process time.
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17) It was also observed that higher rotational speeds generated better mixing and shorter residence times.
18) The authors calculate that the 15cm SDR, bench-top scale, that was constructed and used for their trails had the throughput capacity to generate quote – 8 ton of product per year – unquote.
19) While not a universal fit, this trial strongly supports the further development of SDR processes in the production of pharmaceuticals and chemical in manufacturing.

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