CLEAN CHEMICAL PROCESS BY JET-FLOW REACTOR

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ABSTRACT

Paper describes clean process routes involving Tank reactor, Jet mixer, Mist eliminator and Compressor for Gas-Liquid reaction. The mechanism is illustrated by sulfonation of Para-Nitro-Chloro Benzene (PNCB). The mechanism can be applied to many other Gas-Liquid reactions. Traditionally, sulfonation is carried out using oleum (23%) or sulfuric acid (98%). But use of this acid causes only fractional utilization of the sulfonating agent, remaining all goes as waste acid. This waste acid is contaminated with unused raw material, some overheated and darkened colored material along with other side products. It is not suitable for further use in the process industries. As per current practice waste acid generated is utilized with lime, causing very high consumption of lime and solid products which are difficult to dispose of.

In the proposed process, gases are injected into the liquid bulk through jet and are allowed to be absorbed, and reacted. Here, besides eliminating pollution at source by completely utilizing the raw materials, jet mixer also reduces power consumption for agitation and mixing though with additional power requirement to run compressor. The unabsorbed gas coming out is separated from mist and is recycled back after compression. The mist dripping back into reactor. The recycle gas is added with makeup SO_3 and diluent. Thus, scheme will neither generate liquid effluent nor emit pollutant gases. The current clean chemical process mechanism can further be extended to processes like Hydrogenation, Halogenation, Alkylation, Isomerization and other Gas-Liquid processes. The proposed scheme obviously requires the experimental proof with all safety and environmental issues for sulfonation process.

Keywords: *Sulfonation, Sulfonator, Sulfonation of organic substances, Clean process*

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1. INTRODUCTION:

For all Gas-Liquid reactions normal procedure is to sparge the gas in a tank reactor with agitator or bring gas-liquid countercurrent contact in a tower with packing medium offering high mass transfer area. For all such systems, the gaseous stream leaving is in equilibrium to the prevailing exit condition; hence there is always some unabsorbed solute gas with the exit gas stream. Therefore, the effluent requires end of pipe treatment to make stream pollutant free. The problem can be solved by recycling the gas till the solute component of gas gets completely absorbed and reacted.

2. CLEAN PROCESS ROUTE:

As per this route, the gas is sparged through jet mounted in such a way that the jet projects horizontally, making equal angle with radial direction and with tangent to the circle at the periphery. Please refer fig 1. The two jets are mounted on the baffles but on opposite side. The jets are placed at the lowest end of cylindrical part of vessel.

Tank is filled with liquid reactant and gas is injected via pipe through jet injector into the liquid content. The tangential introduction of gas through jet creates liquid to move radially and acquire circular motion. The radial movement is partly converted to axial motion by other set of two baffles.

Unabsorbed gas moves through the mist eliminator, to retain the moisture in the vessel and the mist free gas is taken to compressor. Please refer fig 2. The mist drips back into reactor. The make-up SO_3 gas and diluent air are added to the recycle stream from a service tank which provides gases to the suction of compressor. The gases are compressed, cooled If required to bring it to suitable temperature by cooling through Fin Tube Heat Exchanger and is sent back to the reactor through jet. This process continues till the sulfonation is over. The heat generated due to sulfonation is removed by coolant in jacket.

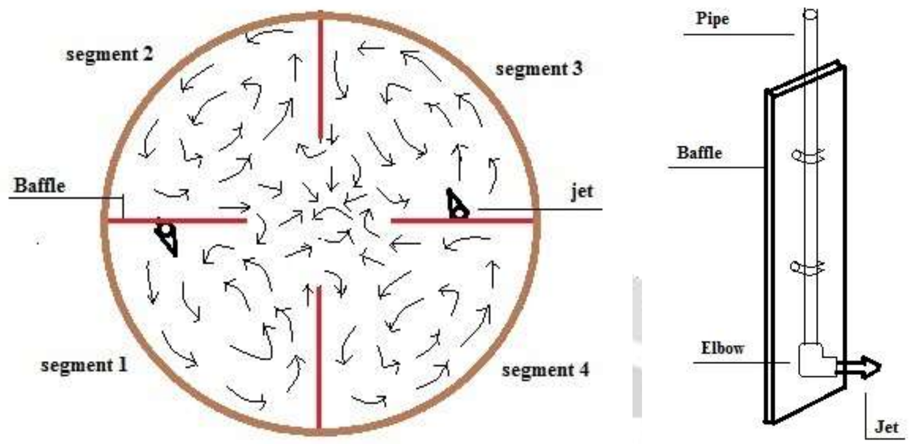

Fig-1: Movement of liquid in tank

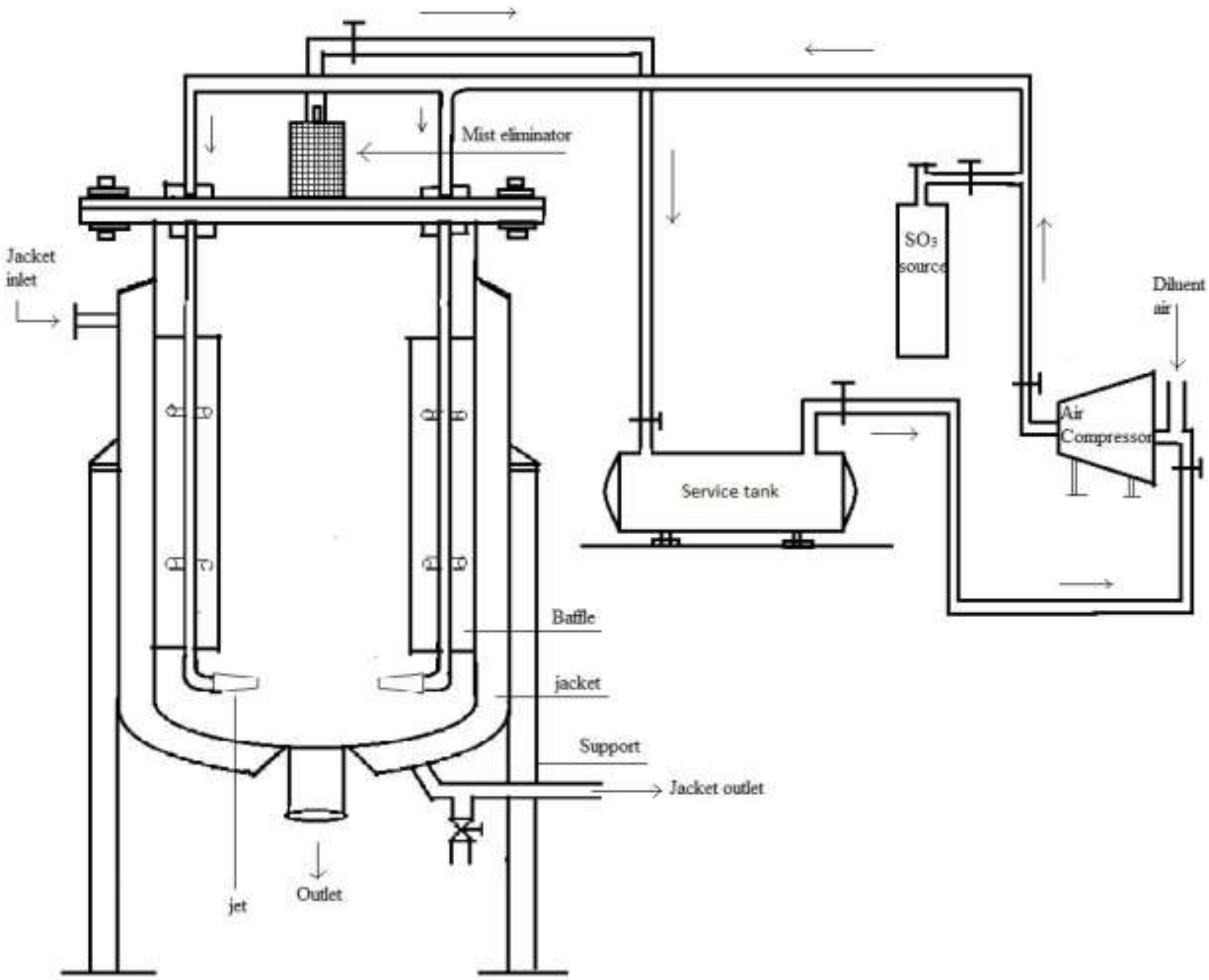

Fig-2: Clean process mechanism

2.1.1 Illustration of sulfonation:

Sulfonation is an important step in Dye making [1]. To demonstrate the clean process route discussed, the sulfonation process is chosen., Sulfonation of PNCB to be more precise [2]. Traditionally sulfonation is carried out using oleum or concentrated sulfuric acid. But this process generates lot of waste sulfuric acid, which is colored and dilute and sometimes contaminated so much that it makes unsuitable for reuse or recycle [2]. Several attempts are in use to convert this acid into salts of metal [4], However, quantity of salts generated in this case is quite large and again difficult to handle. Moreover, it is conversion of one form of pollutant into another form of pollutant but not elimination of pollutant.

2.1.2 Sulfonation by SO_3:

Sulfonation can be carried out using alternative sulfonating agent. If the sulfonation is carried out using liquid or gas SO_3, the problem of waste acid generation can be eliminated, when we use stoichiometric quantity of SO_3. But this will be accomplished by large and rapid heat generation and extensive by product formation in some cases [3]. This can be partly solved by using diluent, such as air along with SO_3 and by providing efficient cooling by increased heat transfer area and by using coolant at low temperature. However, some SO_3 gas will always be there in exit stream. Because quantity equal to partial pressure of gas in equilibrium with liquid solution of gas at exit point will always remain.

Moreover, when we undertake sulfonation process, more than one sulfonated products are generally produced. To selectively produce one specific product, stringent process control/ separation of reactant is required. And even with that it may not be possible to eliminate the co-generation of side product [5].

2.1.3 Using SO_3 as sulfonating agent continuously:

The sulfonation using SO_3 gas can be performed without creating gaseous pollution by recycling unabsorbed gas. The gas which is likely to come out along with mist can be subjected to separation from mist, added with makeup SO_3 gas and diluent and can be recycled.

The recycling can be done by pressurizing the gas. This pressurized gas can act as drive for agitation of liquid in the reactor. This is exactly what is being proposed in the clean process route(mechanism). Please refer Fig 2.

Here the gas is sparged into the pool of PNCB through jet. Jet provides turbulence to the liquid content and rotates it. While rising to the surface, part of SO_3 gas is absorbed and reacted with PNCB to generate sulfonated compound of PNCB. The unabsorbed SO_3 gas with mist passes through Mist eliminator to separate the mist and is sent back to reactor. The clean gas is let out. The clean recycle gas is mixed with makeup gas, diluent and is sent to compressor. The gaseous mixture is compressed to 110 psi. The heat of compression is removed in Fin-Tube heat exchanger. The clean, compressed and cold gas, is then recycled back to the reactor. The process continues till sulfonation is over and gas is completely utilized.

2.1.4 Advantages of Clean Process Route:

1. Complete utilization of gaseous and liquid reactants.
2. No gaseous emission.
3. Total elimination of waste acid generation.
4. Reduction of Chances of leakages as no moving parts are there in reactor.
5. Power required for agitation is eliminated

2.1.5 Disadvantage of Route:

1. Compressor is required to compress recycle gas, diluent and makeup gas mixture. Compression of SO_3 containing gas is yet to be studied.
2. Mist eliminator should work efficiently and should remove mist completely otherwise chances of corrosion and hazard increases with wet SO_3 entering the compressor [6].
3. Severe corrosion can be expected due to SO_3 gas [7].
4. Normally sulfonation produces more than one sulfonated product under the same process conditions. If this is the case, it is difficult to have a control over the process to generate a single desired sulfonated product. Hence purity or quality control may become an important hurdle [3].

3. CONCLUSION:

The clean development route is proposed for all gas-liquid reactions. It is exemplified by reaction of PNCB with gaseous SO_3 to produce sulfonated compound of PNCB. The same route can be used for other gas-liquid reactions with precautions. The list of all such gas-liquid reactions are available in literature [8].

4. REFERENCES:

[1]. Venkatraman K. The Chemistry of Synthetic Dyes, Academic Press: New York, 1952
[2]. Groggins P. H., “Unit Processes in Organic Synthesis”; 5th Edn, Tata Mc-Graw Hill Kogashua ltd. Tokyo 1995,311
[3]. Groggins P. H., “Unit Processes in Organic Synthesis”; 5th Edn, Tata Mc-Graw Hill Kogashua ltd. Tokyo 1995,309
[4]. Report of UNDP, “Naroda Industrial Association”, on waste acid generation at Naroda-GIDC, Gujarat
[5]. Groggins P. H., “Unit Processes in Organic Synthesis”; 5th Edn, Tata Mc-Graw Hill Kogashua ltd. Tokyo 1995,359
[6]. “The Design of Engineered Mist Eliminator”, ACS industries LP, Houston-Texas, USA
[7]. http://www.sciencelab.com/page/S/PVAR/SLS1135
[8]. Joshi J. B., “mixing of fluid”, Proceedings of Chemcon Conference, 2005