This invention relates to a reaction chamber and, more particularly, to a reaction chamber wherein a reaction mixture can digest and also wherein a reaction mixture in different physical states, i.e., a hot reaction mixture and a cold reaction mixture, can be contacted with a minimum of intermixing.

In the preparation of organic sulfonic acid and organic sulfates there may be reacted an alkyl aromatic such as alkyl benzene or xylene. The alkyl benzene may comprise from 8-18 carbon atoms in the side chain and is reacted with the sulfonating agent such as concentrated sulfuric acid, fuming sulfuric acid, chlorosulfonic acid or sulfur trioxide to form a reaction mixture. There is produced a surface active material. Also, unsaturated sulfooxylic acids, i.e., the esters of oleic acid are contacted and mixed with sulfonating agent such as fuming sulfuric acid or chlorosulfonic acid in a centrifugal pump to form a reaction mixture. The alkyl aromatic or unsaturated and the sulfonating agent may be introduced into the pump through two concentric pipes which terminate a fraction of an inch from the impeller blades of the pump. With the pump operating at a high speed the sulfonating agent and the alkyl aromatic or unsaturated are substantially simultaneously contacted and mixed to form a reaction mixture. This mixture is allowed to digest for a few minutes to form a sulfonic acid or an organic sulfonic acid. This is more completely presented in the patent applications of Brooks et al., Serial No. 665,060, filing date of June 11, 1957, and Serial No. 717,358, filing date of February 2, 1958. In the sulfonation of the alkyl benzene, Brooks et al. employed a digestion coil. The reaction mixture flowed through this digestion coil and comprised horizontal passes arranged in a vertical configuration, i.e., the horizontal passes were vertically stacked one above the other, so that the reaction mixture would flow in the bottom of the coil and out of the top of the coil. Each pass or spiral of the coil was in a substantially horizontal plane and the rise would occur from coil to the other coil. This type of coil 10 is more particularly illustrated in FIGURE 1 which shows an inlet coupling 11 and an exit coupling 12. Each pass 13, as is seen from the figure, was in a substantially horizontal plane with the rise 14 between the passes being substantially vertical.

In this type of coil the hot reaction mixture entered the bottom of the coil and left at the top of the coil. After shutting down the apparatus the hot reaction coil would be full of the reaction mixture. Upon standing this mixture would cool and remain in the coil. Then upon starting the apparatus at a later date, i.e., the next morning, the freshly prepared hot reaction mixture would flow into and through the coil. However, instead of flowing evenly through the coil and pushing out the cold reaction mixture there would instead result a stratification of the hot and cold reaction mixtures. More particularly, in each horizontal pass or spiral of the coil the cold reaction mixture would remain in the lower part or bottom of the pipe and the hot reaction mixture would flow in the upper part of the cold mixture. As would be expected, the hot mixture would intermix with the cold mixture. However, the rate of intermixing was slow. For example, after having started and operated the apparatus for about three hours the top of the pipe in a horizontal pass would be too hot to comfortably hold a hand on it while the bottom of the pipe would be substantially the temperature the cold reaction mixture was before starting the apparatus. Because of this stratification there resulted a product of varying physical and chemical characteristics inasmuch as it was not possible to carefully regulate the reaction temperature and the reaction time so as to achieve the desirable degree of reaction. In this regard, insufficient reaction would result in a high free oil content while too much reaction would result in color degradation of the product. With the stratification of the hot and the cold reaction mixtures and the resultant channeling of the hot mixture in the digestion coil there existed the conditions for not realizing the desirable degree of reaction. The hot reaction mixture would not have sufficient residence time in the digestion coil for the reactants to react and therefore there would result an oily product. The cold reaction mixture due to the combination of the long residence time in the digestion coil and the result of heating by the hot reaction mixture would be burned and degraded.

With this limitation of the digestion coil it became necessary to devise a digestion means in which no intermixing of the reaction mixtures would take place. In other words, to realize a more uniform product it became necessary to prevent intermixing of a cold reaction mixture and a hot reaction mixture on start up as the cold reaction mixture would have advanced to a higher state of reaction than the hot reaction mixture. Furthermore, with the passage of time the hot reaction mixture would enhance the reaction in the cold reaction mixture so as to induce a degree of burning. Also, the hot reaction mixture would channel past the cold reaction mixture and in so doing would not remain in the reaction coil for the necessary length of time to allow complete reaction of the hot mixture.

Therefore, I devised a reaction chamber which would minimize intermixing of a hot reaction mixture and a cold reaction mixture upon start up. Briefly, this reaction chamber comprised a vertical tubular member having an inlet for the fresh reaction mixture at or near the bottom of the tubular member and an exit for the old reaction mixture near the top of the member. Accordingly, it is an advantage of the invention to provide a reaction chamber making possible the continuous flow of a reaction mixture therethrough.

A further object is the provision of a reaction chamber which makes it possible to shut down the sulfonating apparatus for a considerable period of time and then to start up the apparatus with a minimum of intermixing and channeling of an old reaction mixture and a fresh reaction mixture inside the reaction chamber.

An additional object is the provision of a reaction chamber making possible the production of a more uniform product.

A still further and important object is the provision of a reaction chamber which is readily adaptable to various flow rates and reaction times making it possible to connect an appropriate number of chambers in the system.

Another object is the provision of a reaction chamber which is inexpensive to manufacture and install.

These and other objects will be more particularly brought forth by reference to the drawings and the complete description of the chamber.

In the drawings:

FIGURE 1 is a schematic illustration of the digestion coil employed in the sulfonation of the alkyl benzene with a sulfonating agent prior to my invention and which digestion coil has been described in a preceding part of the specification; and,
FIGURE 2 is an elevation view of a series of three reaction chambers of the subject invention and which three chambers are connected in series to allow sufficient reaction time. The reaction chamber 20 of this invention comprises a vertical cylinder 21 having a base 22 and a top 23. Near the bottom of this cylinder is an inlet opening 24 in the side wall 21. A pipe 25 passes through the opening 24 and leads into the cylinder. This pipe has a downwardly directed nozzle 26 which terminates a short distance from the base 22.

Inside the cylinder 21 is a vertical pipe 27 which terminates a short distance from the top 23. This pipe 27 at its lower end and near the base 22 bends into a horizontal pipe 28 which passes through an outlet opening 31 in the side wall 21. The horizontal pipe 28 connects with a valve 31. This valve in turn connects with the inlet pipe 25.

I have found it to be desirable to have the vertical pipe 27 at substantially the longitudinal center line of the tubular member 27. This permits a more uniform overflow of the reaction mixture into the member 27.

On the top 23 is an exhaust valve 32 which connects with the interior of the reaction chamber through opening 25 in the top. The chamber may be of any practical height although from experience, I have found a good working height to be approximately six feet. The chamber comprises a vertical outer tube 31 varying from approximately four to eight inches in interior diameter. The vertical inner tube 27 varies from approximately three-fourths of an inch in thickness and one-half inch in internal diameter. The inlet tube 25 is normally of the same size as the vertical tube 27.

By placing the valves 31 between chambers in series it is possible to regulate the flow through the chambers or it is possible to draw off a reaction mixture and thereby eliminate one or more chambers, if desirable, in a specific run. In use a reaction mixture may be introduced into the bottom of the first chamber through the pipe 25. This reaction mixture is directed downwardly and flows substantially to the bottom the cylinder 21, flows outwardly at the bottom and then begins to rise upwardly. Upon rising upwardly it forces upwardly the reaction mixture already inside the cylinder. For example, assume that the apparatus has been shut down for a period of twenty-four hours and the reaction mixture inside the chamber has cooled to approximately 40°F. A hot reaction mixture at the temperature of approximately 175°F, is introduced into the bottom of the first chamber and flows outwardly. This hot reaction mixture then flows upwardly and in so flowing forces upwardly the cold reaction mixture which flows into the top of the vertical tube 27 and out of the chamber. With this chamber it has been noticed that there is substantially no channeling of the hot reaction mixture and that there is a minimum of intermixing of the hot reaction mixture and the cold reaction mixture inside the chamber. The cold reaction mixture from the first chamber flows through successive chambers. Upon the hot reaction mixture leaving the first chamber the hot reaction mixture flows into the second chamber and repeats the process whereby it is introduced into the bottom of the second chamber and flows upwardly uniformly therein so as to sweep out the cold reaction mixture from the chamber.

Although this brief description of the mechanics of sweeping out a cold reaction mixture with a hot reaction mixture has been presented it is to be realized that with this chamber wherein there is a minimum of intermixing of the reaction mixtures there results a better product. Consider that each reaction chamber has a differential horizontal layer which is homogenous with respect to the degree of reaction between the reactants. It is readily realized that there is a difference in the degree of reaction between the differential horizontal layer of the reaction mixture leaving the chamber and the degree of reaction of the differential horizontal layer of the reaction mixture at the bottom of the chamber. If these two reaction mixtures were allowed to intermix, as would be more readily possible with the old type coil employed by Brooks et al., there would be a greater possibility of burning the product in the more advanced differentials layer of the reaction mixture and also with the intermixing there would result a less homogenous product. Also, the channeling of the hot reaction mixture past the cold reaction mixture gives rise to high free oil because this by-pass effectively shortens the reaction time of hot reaction mixture. As contrasted with the digestion coil of Brooks et al. my digestion coil makes it possible to realize a higher degree of conversion of the reactant to an organic sulfonic acid or a sulfonic acid.

These chambers may be used singly or may be grouped together. By being approximately six feet in height it is possible to use them in practically all buildings as there is at least a six foot head clearance. For example, in a building having a low clearance and requiring a relatively long reaction time it is possible to group together a number of these chambers. In this manner there is achieved a long reaction time.

The materials of construction of this reaction chamber depend upon the reaction mixture employed therein. Normally, it is possible to make the reaction chamber from stainless steel or Carpenter Number 20 alloy or glass. In the reaction of unsaturated aliphatics and alkyl benzene with sulfonic acid or a fuming sulfuric acid these materials have been found to be satisfactory.

Having presented my invention what I claim is:

1. A reaction device consisting of at least two identical reactors in series, said reactors each having an outlet and inlet means wherein the outlet means of one of said reactors connects to the inlet means of the other of said reactors, each of said reactors consisting essentially of a substantially vertical chamber having a base and a top and only three openings therein, the ratio of the internal length of said chamber to the internal periphery thereof being greater than unity, a liquid inlet means positioned in one of said openings at the lowermost portion between the ends of the liquid outlet means of said chamber and terminating near the base thereof for introducing a liquid reaction mixture into said chamber, a liquid outlet means secured to an end remote from said inlet opening, the liquid outlet means comprising essentially a conduit having an effluent end remote from said inlet opening, said effluent end functioning as an inlet means for the next reactor in the series.

2. A reaction device in accordance with claim 1, wherein the liquid inlet means is provided with a downwardly directed nozzle which terminates a short distance from the bottom of said chamber.

3. A reaction device consisting of at least two identical reactors in series, said reactors each having an outlet means and an inlet means, wherein the outlet means of one of said reactors connects to the inlet means of the other of said reactors, each said reactor consisting essentially of a substantially vertical chamber having a base and a top, said chamber having only three openings therein, the ratio of the internal length of said chamber to the internal periphery thereof being at least 3 to 1, a liquid inlet means secured in one of said openings at the lowermost portion between the ends of the longitudinal axis of said chamber, and a conduit extending from said base thereof for introducing a liquid reaction mixture into said chamber, a liquid outlet means secured to an
other of said openings having an intake portion near the top of said chamber and substantially surrounding the longitudinal axis of said chamber, and an exhaust valve secured to the third of said openings, said liquid inlet means entering the chamber through the side wall near said base, said liquid outlet means leaving the chamber through the side wall near said base, and said liquid outlet means being in said chamber from said intake portion to the point where it leaves the chamber through the side wall, said outlet means functioning as an inlet means for the next reactor in the series.

4. A reaction device in accordance with claim 3, where-

in the liquid inlet means is provided with a downwardly directed nozzle which terminates a short distance from the bottom of said chamber.

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