

SECTION ON PRACTICAL PHARMACY AND DISPENSING, AMERICAN PHARMACEUTICAL ASSOCIATION

PHARMACEUTICAL EMULSIONS FROM THE COLLOID STANDPOINT.*

BY LEO ROON.

In a previous paper,¹ the writer traced the development of the various theories of emulsification from 1870 to the present time, and showed how diligently physical and colloid chemists have contributed to the knowledge of the subject of emulsions. Hardly a chemical publication is received to-day that does not present some new phase of emulsion work. Yet, we find, in our own specialized field, pharmacy, that practically no progress has been made for seventeen years, toward a clearer conception of emulsions or a proper utilization of colloid chemical ideas on the subject. If we are too practical to develop theory, then let us attempt to apply the available theory to our practice.

Physical chemists state that an emulsion is a very fine distribution of one liquid phase in another liquid phase. For instance, if an oil is added to water, carefully, so that two separate clear layers exist, we have a system consisting of two different homogeneous parts, each of which is called a phase. If the two-phase system is now vigorously shaken, one of the phases becomes finely subdivided in the second phase; and the resultant produced is termed an "emulsion;" although in the case cited, the resulting emulsion is unstable. That phase which is divided into small separate volumes (in this case, the oil) is called the disperse or internal phase; that phase in which the disperse phase is distributed (in this case, the water) is called the dispersion medium, or external phase.

When a pharmacist speaks of an emulsion, he has in mind, apparently, only one type of emulsion; that is, the oil-in-water type, in which the oil is the internal phase, and the water is the external phase. Cod-liver-oil emulsion is an example of this type, the oil droplets being suspended in water through the intervention of the film of emulsifier.

The physical chemist, however, as indicated by his broad definition, does not specify any one particular type—he is acquainted with two general types, the oil-in-water type, just mentioned, and the water-in-oil type.

In the water-in-oil type, water, which is the internal phase, is emulsified in the oil, which is the external phase. Examples of this type are lanolin, lubricating grease, etc.

Strange as it may seem to most of us, the second, or water-in-oil type of emulsion is by far the more important. Holde² shows that lime and alumina soaps are used in the manufacture of lubricating grease, these soaps acting as emulsifying agents for the water (internal phase). Toch, in his "Chemistry and Technology of Mixed Paints," states that mixed paints contain water as the internal phase.

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¹ JOUR. A. PH. A., 5, 496, 1916.

² Zeit. Kolloidchemie, 3, 270, 1908.

Bancroft³ writes, "Since there are said to be twenty million gallons of mixed paints used in the United States, this type of emulsion (water in oil) is unquestionably the more important one commercially; and it is rather extraordinary that the writers on emulsions should have overlooked this important industry."

In order to determine the type to which a given emulsion belongs, either Robertson's⁴ or Briggs' method may be employed. Robertson's method consists in sprinkling a few grains of the bright-red dye, Soudan III, on the surface of the emulsion. Soudan III is insoluble in water, but soluble in oil. Thus, if the color spreads rapidly on the surface, the emulsion has oil as the external phase and is of the water-in-oil type. If the color remains confined to the droplets of oil with which the grains are in actual contact, then water is the external phase and the emulsion is of the oil-in-water type. Briggs' drop method, however, is as efficient and more simple. It consists in placing a drop of emulsion on a glass plate by means of a rod, and adding a drop of water to the drop of emulsion. The two are stirred together. If the emulsified globules spread in the water, it is an emulsion of the oil-in-water type; but if there is no spreading, it is an emulsion of the water-in-oil. The principle involved is that one can dilute an emulsion by adding more of the external phase.

Having at hand, now, the fact that two distinct kinds of emulsions are possible, and also having methods of determining the type to which an emulsion belongs, it will be interesting to take a few preparations in the Pharmacopeia and classify them according to their types; U. S. P. VIII was used.

The official emulsions of almond, asafoetida, chloroform, cod-liver oil and turpentine bring out nothing new. They belong to the oil-in-water class of emulsions. Among the ointments, cold cream presents a strange problem. This preparation may be considered as an emulsion of an emulsion. The mechanism of the reactions in cold cream manufacture is interesting. The almond oil, wax and spermaceti are melted together, and the solution of borax in rose-water is added. The borax solution is alkaline, due to the hydrolysis of sodium borate, and is capable of saponifying the free fatty acids of the almond oil. This small amount of soap formed emulsifies only a part of the oil-wax mixture, since the proportions of the ingredients are not proper for complete emulsification. The two phases of the system now are: (1) Soap emulsion of the oil-in-water type; (2) the melted mixture of oil and wax. The U. S. P. directs to stir rapidly and continuously until congealed. The stirring has the effect of keeping the internal phase (emulsion 1) finely dispersed while the congealing oil-wax mixture envelops the globules of the above emulsion, No. 1.

The rigidity of the finished ointment prevents the coalescence of the globules of the internal phase. Cold cream, by Briggs' test, is an emulsion of the water-in-oil type, the internal phase being an aqueous soap emulsion dispersed or emulsified in the oil-wax mixture, which acts as the external phase.

Mercury ointment conforms to the general definition of emulsion. Mercury is the liquid internal phase; the emulsifier is the oleate of mercury; and the external phase is the lard-suet mixture. Lard and suet, even though rigid at ordinary temperatures, are considered liquids, since they are non-crystalline bodies. The

³ Jour. Phys. Chem., 17, 501, 1913.

⁴ Zeit. Kolloidchemie, 7, 7, 1910.

preparation may be classed with the water-in-oil emulsions, because of the oily external phase, mercury having been substituted for the customary water as internal phase. Quincke⁵ called attention to a similar case in 1888.

Ointment of mercuric nitrate is another example of water-in-oil type of emulsion. The internal phase is solution of mercuric nitrate; the external phase is elaidin.

Concerning hydrous wool-fat, Lewkowitsch, in the "Chemical Technology and Analysis of Oils, Fats and Waxes," states: "Although insoluble in water, wool-wax possesses the remarkable property of absorbing larger quantities of water than any other wax. The emulsion it forms with water has the appearance of a perfectly homogeneous mass. This wool-wax can be mixed with as much as eighty percent of water." Thus, hydrous wool-fat belongs to the water-in-oil type of emulsions.

The ointments of red and yellow mercuric oxides contain ten percent of water, which is used for levigation of the oxides. The forty percent of wool-wax emulsion emulsifies the water and keeps it permanently in suspension.

In mercury plaster, mercury is the internal phase; oleate of mercury, the emulsifier; and the wool-fat-lead-plaster base, the external phase.

Ammonia liniment belongs to the oil-in-water type of emulsions, the cottonseed oil being the internal phase; a mixture of water, ammonia and alcohol constituting the external phase; and ammonium oleate, formed by the saponification of the oleic acid by the ammonia, acting as the emulsifier.

Because we have always been accustomed to consider carron oil, or lime liniment, as an insoluble soap, it is extremely difficult to become reconciled to the fact that it is nothing more than an emulsion of the water-in-oil type. Suppose that 200 Cc. of lime liniment are to be made, using 100 Cc. of lime-water and an equal volume of linseed oil: One hundred cubic centimeters of lime-water contains, at 25° C., 0.14 Gm. of calcium hydroxide, which, if all used up, is capable of forming only 1.2 Gm. of calcium soap, calculated as calcium oleate. Therefore, if all the calcium hydroxide in the lime-water is used up, it has reacted with approximately only 1 Cc. of the linseed oil, and 99 Cc. of the oil remains unchanged. Why, then, call carron oil an insoluble soap? Carron oil is an emulsion in which water (internal phase) is emulsified in linseed oil (external phase) through the agency of the small amount of insoluble calcium soap formed by the interaction of calcium hydroxide and the free fatty acid of the oil.

As a summary, it will be well to quote Newman's⁶ general statement: "Whether one liquid is emulsified in the second, or the second in the first, depends on the nature of the emulsifier." A hydrophile (affinity for water) colloid, like acacia, sodium oleate, etc., will tend to make water the external phase. A hydrophobe (aversion for water) colloid, like magnesium oleate, rubber, etc., will tend to make water the internal phase.

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ABSTRACT OF DISCUSSIONS

H. V. ARNY.—I am convinced that the subject of physical chemistry as applied to pharmacy is one of the greatest possible fields for the professional pharmacist. We have two members of this association, who have started work in this direction. Dr. Wimmer has been engaged in it

⁵ Wied. Ann., 35, 589, 1888.

⁶ Jour. Phys. Chem., 18, 34, 1914.

during the last two years, and lately Mr. Roon has taken up the study. We see the results of it at this moment. Our old fashioned notions about emulsions are bound to be revised, and one of the most interesting things in that connection is that I have been teaching for years that carron oil is an insoluble soap. It never occurred to me to figure out the proportions. I just took the statement of other people.

C. P. WIMMER.—Some years ago I happened to come across an address given before a society of German apothecaries, the Charlottenburg Institute of Pharmacy, by Prof. Thoms, who pointed out some of the practical applications of colloid chemistry to pharmacy. I then started to study colloid chemistry, and found it a field of tremendous possibilities for the practical pharmacist. You have simply to scratch the surface, and there opens a door of new possibilities that are simply unlimited. The trouble is that you must know higher mathematics, which pharmacists, as a rule, do not know. You also must know physiological chemistry well, if you want to do the work thoroughly. Nevertheless, there is no reason why, as we progress, we should not take up this kind of work. Mr. Roon has taken up the manufacture of emulsions. I have been studying viscosity. When I am through with my work, I hope to bring some new facts before you. This work of Mr. Roon shows what can be done. Such work will do more to elevate us in the eyes of scientists, than anything else we could undertake.

L. F. KEBLER.—Some years ago, there was brought before me a product which was sold as lanolin hydrate. The belief being that it was not lanolin, but a mixture of lanolin and petrolatum, I examined it, and could not satisfy myself that it was not pure lanolin; but I referred it back to the chemist, and we finally found that it was a mixture of petrolatum and lanolin. It would mix in all proportions with water, just as the ordinary lanolin does. It is important that the chemist be well qualified to meet extraordinary conditions. In this case, all pharmacopeial methods for identifying the product were unsatisfactory, and it was necessary to establish new methods by which the presence of the adulterant could be established. That required much investigation relative to saponification, emulsification and solubility, as well as all the conditions under which they occur. We finally did establish the presence of the adulterant.

J. U. LLOYD.—Except in eclectic literature, I have made no publications on these lines since 1885. I have been constantly at work since then, however, and have never been discouraged. I agree with our young friend that we have in this field of pharmacy the greatest opportunity that has come to us within the century. It is our field, and we should take advantage of our opportunity. When Dr. Emil Fischer, in Cincinnati, gave a lecture last winter, on emulsions, I was present; and in the discussion, I said that I regretted the fact that from outside of pharmacy had come that study of emulsions. I thought that it was our field. It requires no expensive apparatus; but the apothecary behind the prescription case could, with the addition of a microscope to the ordinary conveniences of a prescription case, accomplish as much as a man in the laboratory.

I remember well the instructions given me by my old preceptor, Geo. Eger, fifty-four years ago, on the subject of the making of emulsions. Generally the rule is applicable, not only to one, but to all, and I believe that it will work as perfectly to-day as it did a half a century ago. If you use it you will find that you first make a watery emulsion in oil, which then turns to an oily emulsion in water. After the emulsion is made, any alcoholic constituent that may be prescribed is added. Sugar is to be added finally. Then you will have an emulsion that will pass the test.

Let me congratulate this society on this paper. Pharmacy is coming into its own. Structural chemistry will still have its place. It need not, and should not be brushed aside; but the study of these substances and their actions on each other, such as class attraction, structural attraction, cohesion, adhesion, etc., is bound to be recognized. These actions all deal with pharmacy in our plant life and animal life.

U. S. P. AND N. F. PROPAGANDA.* A PRACTICAL SUGGESTION.

BY EMIL ROLLER.

The question often arises among pharmacists, "Why is it that the physician

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