

A Radium Experiment.

It is usual to demonstrate the ionising property of radium by discharging an electroscope. The reverse experiment of charging an electroscope, or Leyden jar, is more effective, and can be made to ring a bell.

If a wire, about 6 inches in length, is coated with a salt of radium and placed *in contact* with the knob of an electroscope, the latter will quickly become charged if any charged body is placed within 2 or 3 feet. A small Wimshurst machine is very convenient for the demonstration, as it can be easily turned about to reverse the charge, or placed equatorially, when no effect is produced.

It is a good plan to arrange the leaf of the electroscope to discharge itself automatically to earth at a divergence of about 45 degrees; then the charging is repeated so long as a charged body is in the vicinity. Instead of sending the discharge to earth it may pass into a coherer, and so ring a bell or give a record.

When an induction coil is used it is easy to show that the prepared electroscope will keep on receiving a charge for some minutes after the coil is stopped; for instance, after working an 18-inch coil for one minute, some charge was given to a delicate radium-tipped electroscope when brought into the room four minutes later.

This duration of charge on air can be distinctly shown by filling a large paper bag with charged air and rapidly conveying the same to a Wilson electroscope in another room.

This is obviously due to a residual charge in the air, which persists long after re-combination of mixed ions. This arrangement of a radio-active body near, or, better, in actual contact with, a delicate electroscope is a very sensitive detector. The effect is not quite so good if the radio-active coated wire is placed in contact with the charged body, leaving the electroscope free. Upon exploring the charged air of a room, it is usually found to be divided into two areas of opposite charge; these can be mixed by waving an umbrella, so yielding a neutral mixture.

The fact that a charge is so easily acquired by an electroscope must be taken into consideration during delicate testing, for the mere act of withdrawing a vulcanite pen from the pocket will give a negative charge to a distant electroscope in ionised air.

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SUBSTITUTES FOR RUBBER.

THE present demand for india-rubber naturally directs attention to those articles which, to a greater or less degree, may serve to replace rubber in its industrial applications, and so help in conserving the supply.

Of such articles a very large number have been proposed. Those in actual use to any considerable extent are, however, relatively few. For present purposes the various surrogates may be distinguished as (1) rubber-substitutes proper, consisting wholly of ingredients other than rubber; (2) composite or "artificial" rubbers, which contain a certain proportion of natural rubber worked up with other substances; and (3) true synthetic rubber, namely, a product containing the rubber molecule synthesised in the laboratory or factory by chemical means from simpler compounds.

At present the first of these classes is commercially the most important. Scores of recipes are in existence, including very diverse ingredients; but the basis of most is a modified oil. At first sight there seems little suggestion of india-rubber in the properties of an ordinary vegetable oil, but a simple experiment will indicate the kind of modification which certain oils readily undergo, and which help to fit them for use as rubber substitutes. If we test the drying properties of boiled linseed oil by spreading a little of it over a slip of glass and allowing it to dry, a film of oxidised oil is eventually obtained, having a certain

modicum of toughness and elasticity. The liquid oil has taken up oxygen, and thereby become converted into a more or less elastic solid. Tung-oil substitute is essentially such an oxidised product, manufactured by heating the raw oil until it has absorbed enough oxygen to cause it to thicken and become solid on cooling, when it is powdered and worked up with a little petroleum.

In a somewhat similar way the oils can be made to take up sulphur, becoming thereby solid, and endowed in some degree with elastic properties. The treatment is analogous to the "vulcanisation" of rubber. "Brown" or "black" substitutes are manufactured by heating the oil with sulphur, a process corresponding to the "hot cure" method of vulcanisation. "White" substitutes may be made by merely mixing the oil, cold, with 20 to 40 per cent. of sulphur chloride; or, better, by first dissolving the oil in a suitable solvent such as carbon tetrachloride. This resembles the "cold cure" process used in vulcanising rubber. Colza oil is largely used for these purposes, but various others are available—linseed, maize, arachis, and castor oils, for example. The chemical reaction involved is a somewhat complicated one, but probably it consists mainly in the formation of what chemists term an "addition-product." The proportion of sulphur taken up by the substitutes varies rather widely, ranging from 5 to upwards of 15 per cent. As would be expected, oils which have previously been oxidised to a notable extent (e.g. "blown" oils) require less sulphur to saturate them than do the natural oils.

"Nitrated" oils are also used as the basis of some rubber surrogates. Thus one well-known product is a solution of a nitro-cellulose in linseed or castor oil which has been nitrated by treatment with a mixture of nitric and sulphuric acids. Other such articles are made by oxidising the nitrated oil with lead peroxide, or by simply heating it in air.

These oxidised, sulphured, and nitrated oils, in one form or another, are largely used as substitutes for rubber. Of the other substitutes proposed, a few examples may be given, to indicate something of their general nature.

First there are those which, while still retaining oil as one ingredient, include also other important constituents. Thus, "Fenton's rubber" is a mixture of oils with tar, pitch, and creosote; which mixture, when digested with nitric acid, gives a toughened mass, and this on heating yields an elastic product simulating rubber. "Russian" substitute, said to be useful for covering telegraph cables, contains as ingredients wood-tar, hemp and linseed oils, ozokerite, spermaceti, and sulphur. "Oxolin" is made by impregnating fibrous material such as jute or hemp with linseed oil, oxidising the oily mass with warm air, and working the product up between rollers into a coherent mass, which can then be vulcanised by heating it with sulphur.

In another category of substitutes oil plays only a subordinate part, or is altogether dispensed with. Thus "Jones's substitute" is stated to be made from various gums and gum-like products as the chief constituents. In W. H. Perkin's patent (23,031/07), gelatine or glue is dissolved in creosote and then treated with some reagent—potassium bichromate, formaldehyde, or tannic acid—which will render the gelatine or glue insoluble; after "setting," the mass obtained is digested with acetone to make it firmer. "Textiloid" has for its ingredients various resins, nitrocellulose, and camphor. As a curiosity in this class may be mentioned "grape rubber," produced from the skins of grapes by means of pressure; it is not, however, a commercial article. Finally, though this can only be

a substitute for rubber in very hard articles, we may mention the interesting material, "bakelite," recently introduced by Dr. L. H. Baekeland. It is a condensation-product of formaldehyde and phenol, which can be moulded as desired, and afterwards hardened.

In what sense are the foregoing articles and their likes to be considered as "substitutes" for rubber? Some persons are disposed to deny them any right to the title, and would look upon them as mere adulterants whenever used partially to replace rubber in what would otherwise be an all-rubber article. Others admit, though sometimes grudgingly, that there is a place which such substitutes can usefully fill. Much depends on what the article is sold as, and on what use it is to be put to. Not all the special qualities of rubber are wanted in all the products for which it is employed. A door-mat is one thing, a bicycle tyre quite another. Where a high degree of elasticity is not really needed, as, for instance, in waterproof goods and electrical insulating work, there is a legitimate field for substitutes which may serve the required purpose. Even here they may not be equal to rubber, but they find their justification in their lower cost. After all, we do not need razors to cut sticks with.

It may be said at once that no substitute is equal to rubber in every respect. Chemically, the latter is a very inert substance—much more so than the substitutes. Hence, even if the latter were not otherwise inferior, they would be less durable than rubber under certain conditions. They are nearly all acted upon more or less readily in circumstances where rubber remains unharmed. The modified oils, in fact, are still oils in the sense that they remain glycerides, decomposable by alkalis, as also by steam under pressure. If used for articles exposed to these agencies, they fail in durability, whatever their excellences otherwise.

The fact that substitutes of this class are readily saponifiable by alkali makes it an easy matter to detect them by analysis when compounded with true rubber. As a rule, the proportion of substitute used is from 5 to 25 per cent., and even the smaller quantity is recognisable.

Of the composite rubbers (or "artificial rubbers," as they are sometimes called), one preparation, which has been made in quantity, and is said to be excellent for many purposes, has for its basis Guayule rubber incorporated with certain gums. Another such article is compounded of natural rubber and some other substance of vegetable origin, probably a latex or a gum, reputed to contain the same chemical elements as rubber and in much the same proportion. Such articles are, of course, only partially "substitutes" for rubber, and their cost rises with that of the latter ingredient. Moreover, if any very large demand for them arose, there is always the possibility that the supply of gums and latices would become insufficient, and the advantage of lower cost would thus tend to disappear.

Coming now to true synthetic rubber; a question often asked is whether there exists any probability of such an article being manufactured and displacing natural rubber, either wholly or to any large extent. Will rubber plantations go the way of madder fields and indigo cultivation? Well, the future is on the knees of the gods. In the face of the precedents just mentioned, to say nothing of others, he would be a bold man who would venture to say that even the best quality of rubber may not some day be made on a commercial scale from cheaper materials such as beet sugar and calcium carbide. But the day is not yet. There are beginnings; there are clear indications of the direction in which to proceed; there is distinct

progress to note. But there is still some distance to go, and the end of the journey may not be even in sight.

India-rubber chemically is essentially a polymerised terpene. An article patented some time ago, and named "turpentine rubber," appears to foreshadow a synthesis of true rubber. Turpentine is a mixture of terpenes, and the article in question was to be obtained by passing turpentine through a hot tube, and treating the resulting vapours with hydrochloric acid. The result is a solid condensation-product; and the idea at the base of the process appears to be the production of polymerised terpenes having some of the elastic properties of rubber.

A more promising, because a more scientific way, is that outlined in Heinemann's patent No. 21,772 of 1907. Here a true synthesis is attempted. It is based upon the well-known fact that rubber is probably a polymer of the semi-terpene isoprene. The first step is the production of the unsaturated hydrocarbon divinyl, $\text{CH}_2:\text{CH}:\text{CH}:\text{CH}_2$. This is obtained by passing mixed acetylene and ethylene gases through a heated tube. With methyl chloride, divinyl yields isoprene [methyl divinyl, $\text{CH}_2:\text{C}(\text{CH}_3):\text{CH}:\text{CH}_2$]; and the isoprene on treatment with strong hydrochloric acid is converted by a union of molecules into a substance closely resembling caoutchouc, if not identical with it. The raw materials, so to speak, are thus acetylene, ethylene, and methyl chloride, which are themselves obtained by any of the ordinary methods, e.g. from calcium carbide, alcohol, and beet sugar residues respectively.

The question is, can this or some other comparatively simple synthesis, theoretically quite possible as a laboratory operation, be translated into a practicable and profitable mode of manufacture on a large scale? One of the first doubts to arise is whether the synthesised caoutchouc will have the physical properties of natural rubber; or whether these, by any course of treatment, can be imparted to it. This doubt resolved, there comes the question of economical production in competition with the natural product. Much time and thought have been spent on the problem of synthetic rubber, and it is safe to conclude that there will yet be many a headache before it is solved. Judging by what is known to have been done rather than by the promises, owners of rubber plantations may for the present sleep peacefully in their beds.

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REPORT OF THE ROYAL COMMISSION ON CANALS.

THE Royal Commission on Canals and Inland Navigation, the final report of which has recently been issued, was appointed in March, 1906, and consisted of nineteen members, Lord Shuttleworth being chairman. Their instructions were to inquire into the present condition and financial position of the inland waterways of the United Kingdom; to report as to the causes which have operated to prevent the carrying out of improvements by private enterprise; as to improvements desirable in order to complete a through communication by water between the centres of commercial industry, and with the sea; the prospect of benefit to the trade of the country compatible with a reasonable return on the probable cost; the expediency of canals being acquired by public bodies; and the methods by which funds could be provided for their purchase and improvement.

Seven reports and returns have already been issued, and there are four more to follow, including that on the Irish waterways.