Nov. 13, 1951 G. E. F. BREWER 2,574,528

ELECTRICALLY NEUTRAL ORGANIC LIQUID COMPOSITIONS

Filed March 6, 1947 2 SHEETS—SHEET 1

Fig. 1.

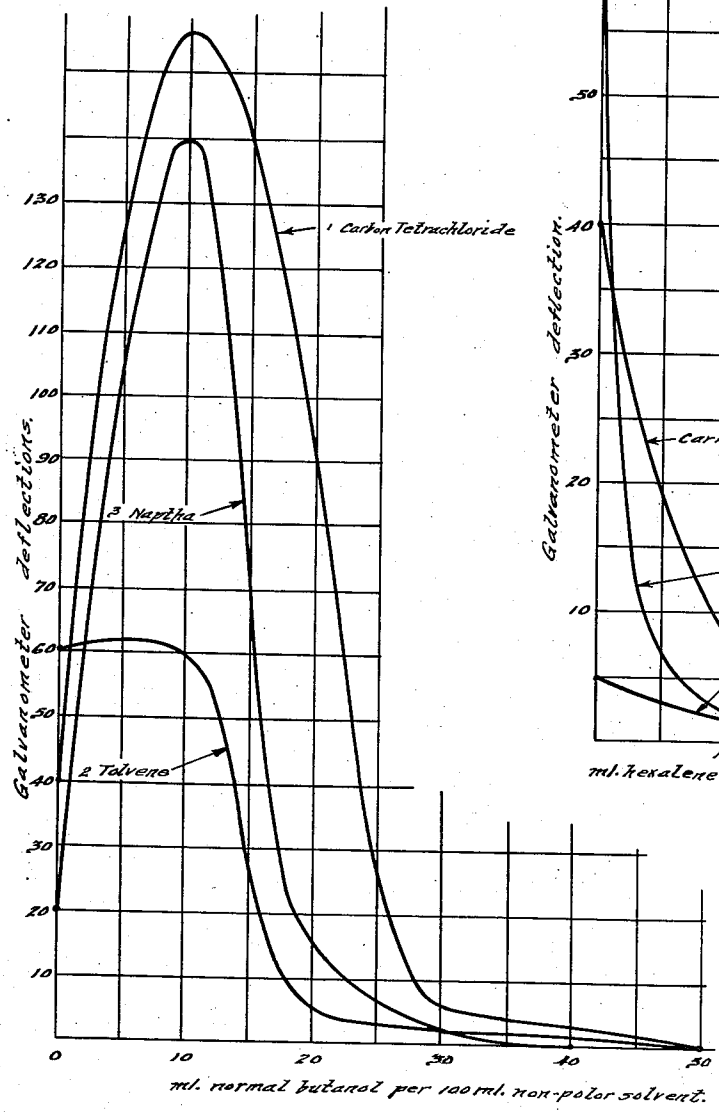
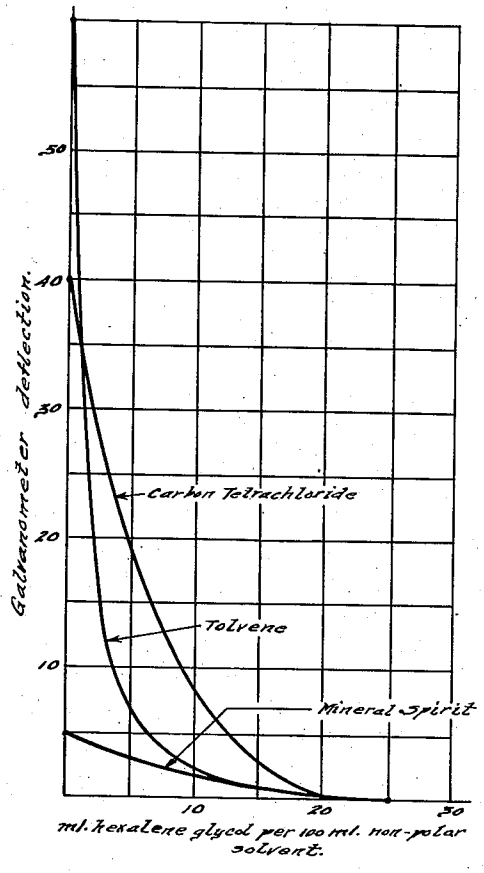


Fig. 2.



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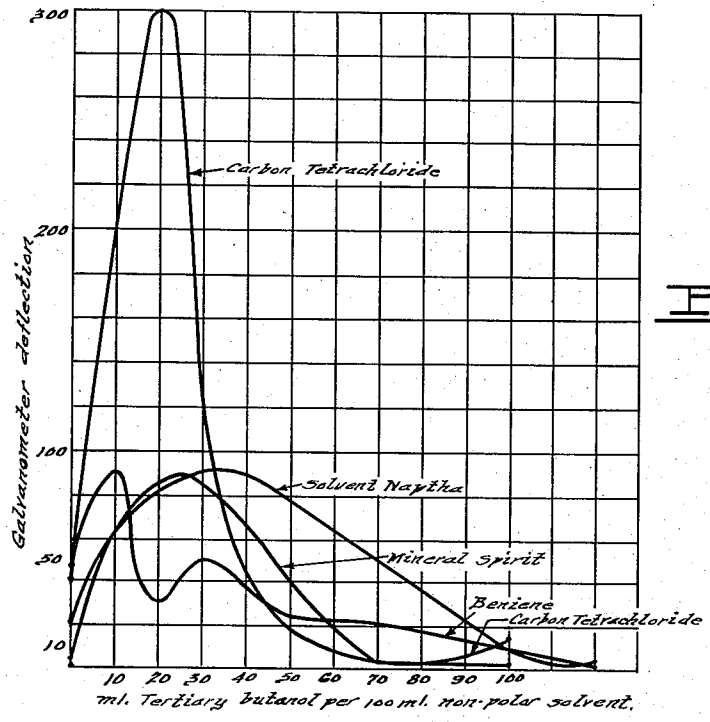


Fig. 3.

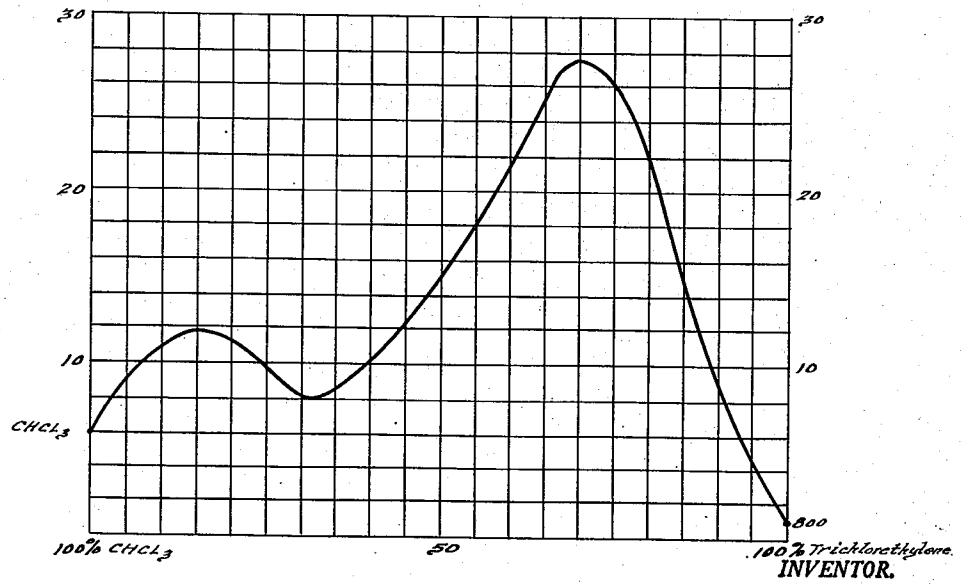


Fig. 4.

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Patented Nov. 13, 1951

2,574,528

UNITED STATES PATENT OFFICE

2,574,528

ELECTRICALLY NEUTRAL ORGANIC LIQUID COMPOSITIONS

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Application March 6, 1947, Serial No. 732,804

5 Claims. (Cl. 252—1)

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The present invention relates to the control of the development of charges of static electricity as the result of agitation or movement of organic liquids relative to other substances.

It has long been known that electric charges are developed during the handling or use of certain organic liquids, and in many cases such charges are hazardous or objectionable. For example, they constitute a fire hazard in connection with the handling or use of inflammable hydrocarbon solvents, such as gasoline, dry cleaning solvents and rubber solvents or plasticizers used in the milling of crude rubber. In the textile industry, they create an objectionable raising of the nap of certain fabrics.

A study of this phenomenon has established that when two bodies which are in contact with each other move relatively, an electric charge is developed. This results on relative movement of two solids, a solid and a fluid, or on relative movement between portions of a body of fluid. Then, when two electrodes are immersed in a body of liquid and moved relatively, and the electrodes are connected by an electric measuring circuit, a flow of electricity through the circuit will be noted as long as the relative movement continues. In the case of organic liquids, which have a very high electrical resistance, very high potentials can build up, but the current flow may still be measured by a galvanometer and a sensitive amplifier. The magnitude of the current flow appears to follow the laws of fluid friction. Thus, within certain speed ranges, the magnitude of the current flow is a lineal function of the square of the relative speeds for any given organic liquid and any given electrodes. The current flow is extremely minute, if both electrodes are relatively smooth metals, but is mutiplied many times if one of the electrodes is a porous material, such as wool, leather, cotton, silk or an acetate, and the other electrode is a metal. This explains the objectionable accumulations of electrical charges in dry cleaning operations.

In the past, it has been proposed that the difficulties encountered with frictionally produced charges in organic liquids be reduced by adding to the liquid a material, such as a soap, which will reduce its electrical resistance and, therefore, make possible a discharge of the frictional electricity through the liquid, itself. By this means it has been possible to effect an appreciable reduction in resistance and, to some extent, to reduce the hazard of sparks. It is found, however, that while such addition agents may reduce

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the resistance of a particular body of liquid to a substantial extent, no appreciable change in the current flow through the above described external measuring circuit occurs. Consequently, these addition agents do not remove the tendency of the system to generate frictional electricity, but act primarily to increase the rate of discharge of such electricity after it is generated. Thus, it is still possible for high potential differences to develop. This possibility of a high potential difference between the electrodes is vastly increased if the organic liquid between them is being violently agitated or is in the form of a spray, since in that case it does not form a continuous conductor. Such conditions are frequently encountered, for example in dry cleaning operations.

It has also been proposed that the static charges be dissipated or neutralized by the use of radioactive substances which emit positively charged rays that will neutralize any negative charge which may have been generated. So far as is known, no commercial use of this system has yet been made. In any event, it is relatively impractical because very powerful radiation would be required to pierce thick layers of material, thus endangering operators.

It is the general object of the present invention to provide a wide range of organic liquid mixtures suitable for use in many fields in which the property of generating frictional electric charges under the circumstances mentioned above may be controlled within relatively wide limits or may be entirely eliminated. As distinguished from the prior mixtures having a reduced electrical resistance, the mixtures of the present invention, although they may also have a reduced electrical resistance, are characterized by the fact that their capacity to generate a flow of electricity may be increased or entirely eliminated, as desired. In those cases in which the liquid mixtures have no capacity to generate an electrical charge (herein referred to as electrically-neutral mixtures), the reduced electrical resistance of the liquid is immaterial and it is unnecessary to provide means for discharging frictional electricity because none is generated.

In the drawings, the several views illustrate in graph form the capacity of a number of organic liquids and organic liquid mixtures to generate frictional electricity under similar conditions.

It has been found that each organic liquid will, under a given set of conditions, induce a current flow differing from that of other organic liquids,

certain liquids having a much greater power to generate a frictional electric charge than others. In accordance with the present invention, the power of any given organic liquid to generate an electric charge or create a flow of electricity under the conditions mentioned above may be either increased or decreased by adding varying quantities of other organic liquids. In many cases, the frictional electricity generating power of the mixture passes through a maximum and minimum value on variations in the relative amounts of the organic liquids in the mixture.

While mixtures of all organic liquids which are mutually soluble evidence this variation in their power to generate frictional electricity, it is the primary object of the present invention to provide solutions which are electrically-neutral, and it is found that, in general, such electrically-neutral solutions may be obtained by combinations of what are usually classified as nonpolar organic solvents, such as straight hydrocarbons and halogenated hydrocarbons, with volatile oxygen containing organic liquid compounds, which are usually classified as polar compounds, the latter group including alcohols, ethers, esters, ketones, glycols, glycerols and other poly hydroxy alcohols. Since most polar organic liquids have negligible current generating capacity, the invention is primarily directed to the problem of controlling that tendency in nonpolar organic liquids.

It is found that dissolving any polar organic compound of the type mentioned in any nonpolar organic liquid, even in small amounts, radically affects the power of the nonpolar liquid to generate frictional electricity. In many cases, as gradually increasing amounts of polar compounds are added to the nonpolar liquid, the capacity of the latter to generate frictional electricity is first rapidly increased and then drops off to zero or substantially zero at a concentration of the polar compound, which varies with different nonpolar compounds but is in most cases approximately the same for a mixture of any given polar compound with all nonpolar organic liquids. In some cases, particularly when the polar compound is hexylene glycol, there is no initial increase in the capacity to generate static electricity, all additions having the effect of reducing the generating capacity of the nonpolar organic liquid.

In any system comprising an organic electrode and a metallic electrode, one of which is moved with respect to a common body of organic liquid, the capacity of the system to generate static electricity varies markedly with the character of the organic electrode. In general, the largest current values result when the organic electrode is wool cloth, while silk fabrics, chamois, rayon cloth, cotton cloth and mercerized acetate cloth generate progressively smaller current flows in the order in which they are enumerated. However, when the capacity to generate electricity of a solution of a given nonpolar organic liquid with a given polar compound is plotted against progressively increasing amounts of the polar compound in the solution, the curves produced by each of the above mentioned organic electrodes will, in most cases, reach their maximum and minimum at approximately the same percentages of polar compound in the solution. While the reason for different current readings for different organic electrodes is not known, there is reason to believe that it is due more to the physical form than to the chemical composition of the organic electrode, the higher readings being obtained with the materials which offer the greatest frictional resistance to relative movement.

The properties of nineteen representative examples of mixtures of polar and nonpolar organic liquids are set forth on the following table. All of the data given were obtained under identical conditions in the following manner.

The nonpolar organic liquid was placed in a tin-plated steel container which was electrically insulated from its surroundings. A constant speed motor-driven rotary paddle was wrapped with the organic electrode material and immersed in the solvent. The paddle was electrically insulated from the drive motor. The sole electrical connection between the paddle and the container was through an external circuit containing an exceedingly sensitive amplifier and galvanometer. The electrical current through the external circuit was measured for the pure nonpolar liquid and for solutions of that liquid with progressively increasing quantities of a polar organic liquid.

The current values given on the following table are in terms of points on the galvanometer scale, but all of the tests were run under identical conditions and, therefore, the values obtained on different tests may be compared to determined relative magnitudes. Each point on the galvanometer scale is calculated to represent a current flow of 3×11^{-11} amperes.

Incidentally, while all of the data given in the table were obtained by tests in which the organic electrode was attached to the rotating paddle, other tests have established that substantially identical readings are obtained when the organic electrode constitutes the lining of the container and the paddle is the metal electrode.

The first column on the table lists the nonpolar liquid in each of the mixtures. The second column gives the current reading for the nonpolar liquid before any additions of polar liquid were made. The value given is that obtained when the organic electrode was wool cloth, since that material gave the highest current readings of any of the electrode materials tested. The third column lists the polar liquid which was added in varying quantities to 100 milliliters of the non-polar liquid. Each of the solutions was tested with a plurality of different organic electrode materials. It was found that two different types of behavior were obtained with different liquid solutions. In some cases, initial additions of a polar liquid increased the current readings to a maximum and further additions reduced the current readings to a minimum. Accordingly, in column 4 is listed the amount of polar liquid in milliliters which was added to the 100 milliliters of nonpolar liquid to produce the maximum current reading. Since there were, in some cases, variations in the maxima for different organic electrode materials, a range of additive is given in column 4. Thus, for example, in solution #8, in which the nonpolar liquid was naphtha and the polar liquid was tertiary butanol, the addition of 16 milliliters of tertiary butanol produced maximum current readings when the organic electrode was cotton or white acetate, an addition of approximately 25 to 30 milliliters of tertiary butanol produced the maximum current value for a chamois electrode, and an addition of 40 milliliters of tertiary butanol produced the maximum current for silk, velveteen, velvet and wool. Thus, in column 4, the

range of additive for maximum current is given as from 16 to 40 for solution #8.

Column 5 gives the value, in terms of galvanometer scale readings, of the maximum current obtained by the additions listed in column 4 when the organic electrode was wool, this being the highest reading in each case. In the case of solution #18, two maxima, one positive and one negative, were obtained. Consequently, in columns 4 and 5, figures for each of the maxima are given. In addition, the amounts of ethyl ether are given in terms of percentage of the total solution by volume, rather than in milliliters per 100 milliliters of the nonpolar compound.

Column 6 gives the amount of polar liquid added to produce a minimum current reading. This also is given as a range, partly because at exceedingly low current values it is difficult to determine the exact zero point and partly because some slight divergence in the zero points of the curves was noted for different organic electrode materials. In most cases, the minimum current value was zero, as indicated by column 7, which lists the minimum current readings obtained for all electrode materials tested. In some cases, no zero reading was obtained for some electrode materials. For example, with solution #6, carbon tetrachloride and tertiary butanol, the curves for all organic electrode materials reached a zero value at approximately 75 milliliters of added tertiary butanol except for the curve for wool, which reached a minimum at a scale reading of approximately 4 on the addition of 75 milliliters of tertiary butanol. Accordingly, the minimum current range for solution #6 is listed in column 7 as from zero to 4.

cally-neutral so long as it is approximately neutral, and, accordingly, it is unnecessary to establish the solution ratio of absolute neutrality in all cases.

In order to set forth in greater detail the properties of certain of the solutions referred to in the above table, the actual curves showing the amount of current generated with a wool cloth electrode for a number of solutions are shown in the drawings in Figures 1, 2 and 3. Thus, in Figure 1 are shown the curves produced by additions of normal butanol to three non-polar liquids, namely carbon tetrachloride, naphtha and toluene. The curves shown in Figure 1 are generally representative of the nature of the curves obtained with solutions of most polar and nonpolar organic liquids. Thus, it will be noted that in the case of carbon tetrachloride, the current generating capacity of the pure nonpolar liquid was 40 on the galvanometer scale but increased to a maximum of almost 160 on the addition of only 10 milliliters of normal butanol. Further additions of normal butanol reduced the current generating capacity to only 6 unit at 30 milliliters of normal butanol and to zero at 50 milliliters of normal butanol. A similar curve was obtained with naphtha except that the current generating capacity of the pure naphtha was approximately 20 units, its maximum was 140, and it reached a minimum of zero on the addition of approximately 38 milliliters of normal butanol. Toluene differed slightly in that it had a much lower maximum, very little above the current generating capacity of pure toluene. In the case of toluene, the current generating capacity was reduced to a very low value on the addition of 25 milliliters of butanol and to zero on the addi-

	1	2	3	4	5	6	7
	Nonpolar Liquid, 100 milliliters	Current for 100% Nonpolar Liquid (Wool Electrode)	Polar Liquid	Amount of Polar Liquid for Maximum Current (range for all electrode materials)	Maximum Current (Wool Electrode)	Amount of Polar Liquid for Minimum Current (range for all electrode materials)	Minimum Current (Range for all electrode materials)
				Milliliters		*Milliliters*	
1	Carbon Tetrachloride (Fig. 1)	40	Normal Butanol	10	160	30 to 50 [1]	0
2	Toluene (Fig. 1)	60	do	0	60	20 to 50 [1]	0
3	Naphtha (Fig. 1)	20	do	10	130	20 to 40 [1]	0
4 [2]	Benzene	50	Iso-butanol	0 to 20	70	40 to 70 [1]	0
5	Naphtha	20	do	10	90	40 to 60 [1]	0
6	Carbon Tetrachloride (Fig. 3)	40	Tertiary Butanol	20	300	70 to 80	0 to 4
7 [3]	Benzene (Fig. 3)	50	do	0 to 10	90	70 to 100	0 to 4
8	Naphtha (Fig. 3)	20	do	16 to 40	90	100 to 120	0 to 6
9	Mineral Spirits (Fig. 3)	5	do	25	90	75 to 100	0 to 2
10	Mineral Spirits	5	Secondary Butanol	20	40	35 to 65 [1]	0
11	do	5	Cyclohexanol	7.5	30	75	0
12	do	5	Hexanol	20	60	100	2
13	Mineral Spirits (Fig. 2)	5	Hexylene Glycol	0	5	20 to 25 [1]	0
14	Carbon Tetrachloride (Fig. 2)	40	do	0	40	20 to 25 [1]	0
15	Toluene (Fig. 2)	60	do	0	60	20 to 25 [1]	0
16	Diisobutylene	3	do	2	80	20 to 25 [1]	0
17 [1]	Carbon Tetrachloride	40	Methyl Ethylketone	0	40	20 to 25 [1]	0
18 [1]	do	40	Ethyl Ether (absolute).	Positive, 20%. Negative, 100%.	Positive, 40. Negative, 90.	65%	0

[1] Remained neutral for larger additions up to 100 ml.
[2] Negative dips for some electrode materials at lower concentrations than neutral.
[3] Negative dips for some electrode materials at higher concentrations than neutral.

It will be understood that the current values given in the above table are relative and are subject to the usual experimental errors unavoidable in measuring values of the magnitude here involved. The data, however, provide a reliable guide for the preparation of solutions having any desired current generating characteristics. For many practical purposes, it may not be necessary to utilize a solution which is absolutely electrition of 50 milliliters of butanol. The curves given in Figure 1, since they are those obtained with the use of a wool cloth electrode, are in general higher than those obtained with other organic electrode materials, but in general the maxima and minima of the curves occur at approximately the same additions of normal butanol.

In some cases, particularly when hexylene

glycol is utilized as the polar liquid, strikingly different curves were obtained for most nonpolar solvents, as indicated in Figure 2. As there shown, additions of hexylene glycol to carbon tetrachloride, toluene and mineral spirits produce no maxima, but in all cases reduce the current generating capacity. This same characteristic was noted on additions of hexylene glycol to other nonpolar liquids, with the exception of diisobutylene, which, as indicated on the above table, produced a maximum current reading on the addition of approximately 2 milliliters of hexylene glycol and a zero reading on the addition of 20 to 25 milliliters of hexylene glycol. Moreover, the current generating capacity for all of the nonpolar liquids reaches zero on addition of the same amount of hexylene glycol, namely 20 to 25 milliliters. It was further noted that even with different organic electrode materials, the zero point was obtained at approximately the same addition of hexylene glycol. Moreover, in all cases on further additions of hexylene glycol, the solution remained neutral.

While in general all of the solutions tested produced curves conforming generally to the patterns appearing in Figures 1 and 2, somewhat more erratic curves were obtained with certain polar liquids, particularly tertiary butanol. Accordingly, the curves obtained by the additions of tertiary butanol to a number of nonpolar liquids are given in Figure 3. As there shown, the curve for carbon tetrachloride reached an exceedingly high maximum of 300 current units on the addition of only 20 milliliters of tertiary butanol. This curve otherwise conforms to the general pattern of Figure 1 except that in no case did the curves reach the zero or neutral point when the wool cloth electrode was used. This latter characteristic was not noted for other electrode materials, all of which reached zero at approximately 75 milliliters of tertiary butanol and did not increase on further additions. The curves in Figure 3 for naphtha and mineral spirits are more or less conventional except that they reach their zero or minimum points at appreciably different additions of tertiary butanol. The curve for benzene is unique in that it has two maxima at additions of 10 and 30 milliliters of tertiary butanol, respectively. While the curves of Figure 3 are more erratic than those normally obtained, it will be apparent that even in such cases it is possible to produce solutions which are neutral or substantially neutral with respect to their capacity to generate frictional electricity.

It will be apparent to those skilled in the art, from the diverse character of the numerous polar and nonpolar liquids listed in the above table, that comparable results may be obtained by a mixture of any polar organic liquid with any nonpolar organic liquid, so long as the two are mutually soluble. It will only be necessary to determine by simple experiment the relative proportions of the two liquids required to produce the desired properties. Moreover, in cases where the selected polar and nonpolar liquids are not in themselves mutually soluble, either because of their inherent characteristics or because of the presence of some third material, they may be combined to produce the desired results by the use of a mutual solvent. For example, certain of the polar liquids listed in the above table are insoluble in the nonpolar liquids if minute quantities of water are present. The presence of minute quantities of water is rendered likely by the fact that certain of these polar liquids are hygroscopic. For example, hexylene glycol, which, in a pure state, is soluble in mineral spirits (see solution #13), separates completely in the presence of minute quantities of water. It is found, however, that additions of hexanol to the solution maintain the two liquids in solution even though water is present. For this purpose, approximately one per cent hexanol is required for each one-tenth of one per cent of water present. Thus, a solution of 100 milliliters of mineral spirits, 25 milliliters of hexylene glycol, 13 milliliters of hexanol, and water not exceeding approximately 1.3 milliliters, produces a stable and electrically-neutral solution.

Other polar liquids, such as propylene glycol and glycerol, are similar to hexylene glycol in that they will not dissolve in certain of the nonpolar liquids, such as mineral spirits, in the presence of water, but may be so combined by additions of hexanol to produce a neutral solution. However, in the case of propylene glycol and glycerol, relatively large additions of hexanol are required to produce the desired result, and this may be undesirable for some purposes. Other alcohols may be used as the mutual solvent, if desired, but the best results have been obtained with hexanol.

Hexanol is itself a polar liquid capable of producing a neutral solution with a nonpolar liquid, as indicated by solution #12 on the above table. It is apparent, therefore, that in place of a single polar liquid, solutions of two or more polar liquids may be employed to neutralize nonpolar liquids in accordance with the principles outlined above.

While in general it is not possible to produce entirely neutral solutions in the absence of a polar liquid, it has been found that combining two nonpolar organic liquids in varying proportions materially affects the current generating capacity of the solution and in some rare instances does produce a neutral solution. Thus, for example, solutions of benzene and carbon tetrachloride in almost all proportions have a substantially constant current generating capacity except that the current generating capacity is sharply decreased by from thirty to sixty per cent when the solution contains approximately sixty-five per cent carbon tetrachloride and thirty-five per cent benzene.

Chloroform is only slightly polar since it contains no oxygen and, accordingly, is found to act in general as a nonpolar liquid. For example, chloroform, alone, will generate a current of 9 units for a wool electrode but may be rendered electrically neutral for all electrode materials by the addition of from 5 to 25 parts of hexylene glycol to 10 parts of chloroform under the circumstances described in connection with the above table.

In addition, in Figure 4 is illustrated the effect on the frictional electricity generating capacity of variations in the proportions of solutions of chloroform and trichlorethylene. From this curve it will be apparent that a very substantial increase in frictional electricity generating capacity is obtained at approximately seventy per cent trichlorethylene and thirty per cent chloroform. Another example of mixtures of organic liquids which have a striking variation in current generating capacity is that comprising mixtures of benzene and chloroform. While pure benzene produces a current generating capacity of approximately 50 points on the galvanometer

scale under the conditions described above and pure chloroform a current generating capacity of approximately 9 points on the galvanometer scale, a maximum of 200 points on the galvanometer scale is produced by a mixture containing seventy-five per cent benzene and twenty-five per cent chloroform.

As a general rule, the polar organic liquids have negligible current generating capacities in a pure state. A striking exception has been noted in the case of ethers. Thus, for example, under the conditions described above, pure ethyl ether produces a galvanometer reading of 90 points on the scale and isopropyl ether a reading of 40 points. Moreover, the polarity of the current generated in ethers is opposite to that generated in the nonpolar organic liquids referred to above. This explains the relatively high negative maximum reading obtained with pure ethyl ether, as noted on the above table in connection with solution #18.

It has been found, further, that the relatively high negative current generating capacity of ethers may be neutralized completely by additions of other polar organic liquids in the same manner as the latter neutralize nonpolar organic liquids. Thus, three per cent ethyl alcohol or twenty per cent hexylene glycol will neutralize ethyl ether or isopropyl ether.

The advantage of increasing the frictional electricity generating power of an organic liquid has not hitherto been recognized, but there is evidence to support the conclusion that the tendency of such liquids to enter into chemical reactions is enhanced on an increase in their frictional electricity generating power.

While, as previously indicated, the electrically-neutral solutions of the present invention may be utilized to advantage in a wide variety of fields, it is believed that solutions of nonpolar dry cleaning solvents, such as carbon tetrachloride, trichlorethylene, naphtha or mineral spirits, with hexylene glycol of the formula

$$(CH_3)_2 \cdot COH \cdot CH_2 \cdot CH(OH) \cdot CH_3$$

are peculiarly useful for dry cleaning clothing, and particularly woolens. The practical range for the proportions of such a solution is from approximately one and a half to three parts by volume of hexylene glycol to approximately six parts by volume of the nonpolar solvent. For this purpose, it is desirable that the solution also contain hexanol, in order to impart to the solution a tolerance to small quantities of water. From one-half to two parts by volume of hexanol in the above mentioned solution would ordinarily be sufficient for this purpose, although greater quantities may be required if water in excess of one-fourth of one per cent is present. The complete solution is not only highly effective as a dry cleaning solvent, but the mixture, because of its capacity to absorb water and dissolve water soluble materials, will obviate the necessity of using the customary dry cleaning soaps in most cases. While other polar organic liquids may be substituted for hexylene glycol in dry cleaning solutions of the type mentioned, hexylene glycol or normal butanol are preferred because smaller quantities are required to produce an electrically-neutral solution.

The following table gives in parts by volume the range of quantities of different polar organic liquids required to produce substantially electrically-neutral solutions with ten parts by volume of any mutually soluble nonpolar organic liquid, and also the approximate quantity which appears to give the minimum frictional electricity generating capacity:

	Range		
Hexylene glycol	1½	to 10	2½
Normal butanol	3	to 10	5
Iso-butanol	4	to 10	6½
Tertiary butanol	7	to 16	15
Secondary butanol	5	to 10	6½
Ethyl ether	10	to 20	15
Cyclohexanol	5	to 10	7½
Hexanol	8	to 12	10
Methyl ethylketone	1½	to 10	2½

A range of proportions is given in part for the reason that commercial grades of the same compounds obtained from different sources evidence appreciably different electrical generating capacity and in part for the reason that for many purposes it is unnecesary to obtain an absolutely neutral mixture in order to obtain the benefits of the invention. Any solution coming within the ranges specified will have a current generating capacity materially less than that of the pure nonpolar liquid.

While numerous specific examples of organic liquid mixtures are specifically set forth herein, it will be apparent to those skilled in the art that many other solutions of polar and nonpolar organic liquids are possible and that, by combining them in proper proportions, electrically-neutral solutions may be obtained within the spirit of the invention and the scope of the appended claims. While the examples given are all liquid solutions, it is believed obvious that the principles of the invention are applicable to "solutions" which are normally gaseous or solid. Thus, mixtures of polar and nonpolar gases which are electrically-neutral may be obtained. Likewise, organic solids, such as certain plastics and resins, may be made electrically-neutral by the addition of polar organic compounds which will remain in solid solution in the final product.

What is claimed is:

1. An electrically-neutral liquid solution comprising approximately ten parts by volume of a nonpolar organic liquid which when substantially pure has the property of generating static electricity at an interface with a solid with which it is in mobile contact, and from one and one-half to ten parts by volume of hexylene glycol of the formula $(CH_3)_2 \cdot COH \cdot CH_2 \cdot CH(OH) \cdot CH_3$.

2. An electrically-neutral liquid solution comprising approximately ten parts by volume of a nonpolar organic liquid which when substantially pure has the property of generating static electricity at an interface with a solid with which it is in mobile contact, from one and one-half to three parts by volume of hexylene glycol, and from one-half to two parts by volume of hexanol.

3. An electrically-neutral liquid solution comprising approximately ten parts by volume of mineral spirits, from one and one-half to three parts by volume of hexylene glycol of the formula $(CH_3)_2 \cdot COH \cdot CH_2 \cdot CH(OH) \cdot CH_3$, and from one-half to two parts by volume of hexanol.

4. An electrically-neutral liquid solution comprising approximately ten parts by volume of mineral spirits and one and one-half to ten parts by volume of hexylene glycol of the formula $(CH_3)_2 \cdot COH \cdot CH_2 \cdot CH(OH) \cdot CH_3$.

5. In a system wherein a non-polar organic liquid selected from the class consisting of naptha, toluene, benzene, mineral spirits, and carbon

tetrachloride is in a container and is in mobile contact with a solid surface and wherein static electricity is produced by such contact when the non-polar liquid is substantially pure, the improvement in the system which comprises essentially a hexylene glycol dissolved in said non-polar liquid in the proportion of one and one-half to ten parts of said glycol to each ten parts of said non-polar liquid.

GEORGE E. F. BREWER.

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