CHEMICAL ADHESIVE ELECTRODE

ABSTRACT: An electrically conductive mixture is provided for use as contact media in electro-medical applications such as electro-encephalography. The mixture comprises an electrode jelly, kaolin and aqueous alcohol. Prior to use it is contained in jars as a paste-like material. During use on exposure to air it hardens rapidly keeping the electrodes firmly in place with excellent capacity for electrical conductance through the electrode.
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This invention relates to mixtures of chemicals that may be used as electrical conductors. More particularly, it relates to mixtures which function to hold electrodes in place while at the same time acting as electrical conductors.

In electrocardiography, electroencephalography, and electro-shock therapy a number of skin contact media including electrode jellies and pastes are commercially available. The function of most skin contact media is to provide a system which enhances the electrical conductivity between a machine electrode and the body of a patient. Generally electrode jellies and pastes are gummy or pasty substances containing an electrolyte. Some electrode jellies are gel systems which contain gelling agents such as alginates or cellulose gums and ionizable salts such as sodium chloride. Other electrode jellies are emulsions some containing self-emulsifying mineral oil and others surface-active materials such as long chain fatty acid esters or polyethers of carbohydrate materials. For electrocardiographs, jellies high in salt content, jellies low in such, abrasive-free lubricants, and even water by itself have been used as the material for lowering the electrical resistance between the instrument electrode and the patient’s body. However, in electroencephalography great difficulty has been encountered in keeping the electrodes in place.

When one is working with a cooperative patient the difficulty is not so great in many cases but is uneconomic due to the patient’s age or lack of understanding. In such cases repeated dislodging of electrodes makes it most difficult and time consuming to get proper results. The problem is further aggravated by the fact that many of the contact media are skin irritants, difficult to apply, or are difficult to remove after being applied. Again, the contact media frequently hardens and loses all or substantial parts of its conductivity. Thus, there is a need in electroencephalography for a material which has none of these disadvantages, but affords a convenient, acceptable contact holding the electrode fast physically and yet retaining its capacity for high electrical conductance.

Therefore, an aim of this invention is the provision of a material which is electrically conductive. Another purpose is providing such a material that is not irritating to the human skin. A still further object is to provide a material which will act as a cement or sealant to hold an electrode in place while at the same time affording a portion for electrical conductance. These and other goals will become apparent from the following description.

The objectives of this invention are accomplished by the provision of a mixture of kaolin and an electrolyte and in a preferred form a mixture containing these ingredients and an alcohol. The ingredients are blended together in such proportions that a paste is formed which, when exposed to air, dries rapidly acting as a cement but which when kept from exposure to air stays moist and retains its conductivity.

These and other objects will be seen in the following description and in the drawings all of which is given for illustrative purposes and is not figurative, the figures being as follows:

FIG. 1 is a pictorial view of a typical electrode; and
FIG. 2 shows the cup end of the electrode immersed in the composition of this invention.

As shown in FIG. 1 the electrode consists of a jack or plug 1 connected by a wire 2 to an electrode cup 3. In use with an encephalograph or other instrument, the cup 3 is placed in conductive contact with the desired portion of the patient's skin and the plug 1 is inserted into the proper receptacle of the instrument, shown fragmentally as jack 4 shown in FIG. 2.

Also shown in FIG. 2 is an amount of the conductive material 5 of this invention which has been placed on the skin surface 6 of the patient being examined. The cup 3 is then immersed in the paste shortly after the paste is applied and for a time portion of the composition of this invention which is exposed to air hardens. Once hardened, it adheres to the skin and the cup 3 becomes embedded in a solidified material so that it cannot readily be dislodged as, for example, by the tossing and turning done by a baby being examined or a fiddly child. To aid hardening, cotton or other absorbent material is placed immediately over the material of composition 5. This aids in drawing excess fluid from the outer layer of the material 5 and also helps in insulating the electrode from adjacent hairs, for example. The material of composition 5 which is generally directly underneath the cup, has been cross-hatched differently from the other and is designated as element 7. This material comprising element 7 remains moist and retains its high electrical conductivity for a long period of time. This enables the technician to place the other electrodes with assurance that the immediate one just placed will not fail off before placement of all is completed and that all those placed will be electrically conductive when the recording is being effected.

The particular conductive materials used in the composition depend on fluidity and the degree of ionization required. The hardening of the outermost portions in the application of the composition of this invention is an important element. As described, it acts as a cement and locks cup 3 in place. Secondly, the hardening creates a barrier to any fluid material under the cup that seeks to escape by vaporization or other means. Thus, the fluidity needed for conductivity is preserved right in the regions where it is needed.

In considering what materials may be used to produce the compositions of this invention, one recognizes that any conductive material can be placed under the cup, acting as element 7 in FIG. 2 and that this material can be different than or the same material as the outermost sealing material. To illustrate one could place a conductive material on the skin, then immerse the cup electrode 3 in it and then cover the entire assembly with a cement such as collodion. However, the use of different materials and extra steps is avoided by this invention, for the conductive material acts both as a cement and as a conductor. It is, however, revealant to note the stated use of other materials, for the compositions of many of the conductive jellies which are available commercially and which may be used in this invention are not known, the producers choosing to keep the formulations secret. However, among the electrically conductive materials which may be used in this invention are soft green soap, an almost neutral mixture of potassium oleate and glycercin, or electrode pastes or jellies rich in salts or other electrolytes. Various conductive materials which may be used are described in such publications as Electrode Jelly in Electrocardiography, by David Lewis, British Heart Journal, Vol. XXVI, No. 1, page 105—115 dated January, 1965; and U.S. Pat. Nos. 2,555,037; 2,782,786; 3,027,333; 3,048,549; and 3,187,745. A specific jelly is one containing the following ingredients (by parts): glycerol (5.0) starch (10.0), sodium chloride (29.0); distilled water (100.0), and methyl p-hydroxybenzoate (0.2). This jelly is simply prepared by first making a paste of the starch by adding 20 parts of cold distilled water and stirring until smooth. Next add the sodium chloride, methyl p-hydroxybenzoate and glycerin to the remainder of the water. Mix the two solutions, add the pumice if desired, heat to boiling, stirring until a uniform paste is formed.

Certain jellies contain one percent or less of an ionizable salt, such as sodium chloride, while others have around eight percent of such and still others are very high in salt content, the percentage being 13—15 percent. Although many jellies are available, the jelly that is preferred in this invention is Cambridge jelly. This jelly, as indicated in the Lewis publication, has a chloride of an amount of eight percent. While it is preferred, this invention is not limited thereto, for the gist of the invention resides in the double function of the composition of this invention as cementitious and as conductive materials. As is known, most of the electrode pastes and jellies and the like are adjusted to have a pH within the range of about 4.2 to about 6.0 to approximate the pH of the skin. Thus, any electrode material having a pH within this range may be used in the compositions and assemblies of this invention.
In making the composition of this invention about 12 to about 19 ounces of a conductive jelly, such as one of those described above, is prepared or purchased and thoroughly mixed with about 13 to 20 ounces of kaolin. Thorough mixing is most readily achieved by slowly adding the kaolin to the jelly while mixing. Ordinary kaolin available for prescription compounds is suitable. Preferred compositions are prepared using 15 to 17 ounces of Cambridge jelly with 16 ounces of kaolin. Other preferred compositions are made using 15 to 17 ounces of Cambridge jelly with 16 ounces of kaolin and an amount of an alcohol, such as ethyl alcohol, about one ounce, to get the desired fluidity. The amount of alcohol may be as low as about 0.5 ounce to about 2.5 ounces. With a cooperative patient, the technician prefers to use a material which is as moist as possible to get best conductance, but if too little kaolin is used, the fluidity is too great and the material runs and does not properly set. On the other hand, if too much kaolin is used, the resultant mass is too dry and either does not conduct at all or its conductivity is too low.

As is known, kaolin is an aluminum silicate and is defined in Webster’s New International Dictionary, second edition (1934) p. 1,352 in part as:
“A very pure white clay, ordinarily in the form of an impalpable powder, used to form the paste of porcelain; china clay; porcelain clay. It is a hydrous silicate of aluminum in $\text{H}_4\text{Al}_2\text{Si}_4\text{O}_{10}$, and derived from the decomposition of aluminous minerals, especially feldspar.”

Surprisingly, it has been found that kaolin surpasses other clays or similar materials. For example, one would expect bentonite to be equally as good, but bentonite frequently causes severe and prolonged irritation of the skin in many patients.

Other alcohols may be used in the preferred compositions of this invention. These include absolute alcohol (ethanol) as well as methanol, isopropyl alcohol, butanol and the like as well as other hygroscopic materials such as the glycols and glycerol. Usually 70 percent aqueous ethanol is used and is preferred. Distilled water may be substituted for the alcohols if desired, but does not provide the many advantages of alcohol. The compositions of this invention are readily removed from the skin after use. The alcohol or water act as a lubricant, and they help maintain the fluidity and high conductivity needed at the inside areas where conductivity is occurring.

Alcohol is particularly advantageous in that it evaporates rapidly at the outermost areas where the sealing is to be effected, and this leads to rapid drying and enhances cement formation. Also, while cleaning is readily effected with all the compositions of this invention, the compositions of this invention containing alcohol are easier to clean from the test areas than those without alcohol. Additionally, the alcohols act as anti-bacterial agents to provide antiseptic qualities to the composition of this invention.

From the above it can be seen that this invention affords the technician in electroencephalography conductive materials which are easy to handle and which function very quickly in a safe, non-irritating way. They afford repetitive use of the same procedures with assurance that the work done will be operable and dependable.

While the invention has been disclosed herein in connection with certain embodiments and certain structural and procedural details, it is clear that changes, modifications or equivalents can be used by those skilled in the art, accordingly, such changes within the principles of the invention are intended to be included within the scope of the claims below.

I claim:
1. An assembly for use in electroencephalography for measuring an electrical current when placed in contact with a surface such as on a human's head, which assembly comprises an electrode in combination with and fixedly embedded in an electrically conductive mixture comprising kaolin and an electrolyte, said kaolin being uniformly mixed in said mixture, said mixture being electrically conductive in the inner portion of said mixture and being in electrical conducting relationship with said electrode and said mixture at its exposed and outermost portion being hardened and in a supporting and holding-in-place relationship with said electrode during use of said assembly.
2. An assembly in accordance with claim 1 in which said mixture contains about 13 to about 20 parts of kaolin and about 13 to about 20 parts of said electrolyte.
3. An assembly according to claim 1 which contains ethyl alcohol.