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ELECTRICAL INSULATING REFRACTORY COMPOSITION OF FUSED MAGNESIUM OXIDE AND SILICA OR ALKALI METAL SILICATES

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ABSTRACT OF THE DISCLOSURE

A granular refractory heat conductive electrical insulating composition, which composition may be used for sheathing electrical elements. The composition consists of in admixture 99.9–80.0 weight percent of fused magnesium oxide and correspondingly 0.1–20.0 weight percent of an additive which may be either silica, earth-alkali silicates, earth metal silicates, carbon silicates, clay or mixtures of the above and wherein the composition must contain less than 5 weight percent of either an alkali metal salt or an alkali metal oxide. The preferred additive is quartz.

This invention relates to a heat conductive electrical insulating composition for use in sheathing electrical elements and to a sheathed electrical heating element.

Sheathed electrical heating elements have found extensive use in many heating applications. These sheathed electrical heating elements consist of a metal sheathing, an electrical insulating embedding material and an electrical heating element. The success and key to such heating elements has been the particular electrical insulating embedding material employed therein. Generally, the embedding material is a fused magnesium oxide which is employed because of its excellent thermal conductivity while maintaining high electrical resistivity.

Because temperature and continual use degrades the insulating material, many different combinations of materials have been investigated and tried without much success. The embedding compositions tried were not stable over the wide temperature range required or the electrical resisitivity dropped considerably or the thermal conductivity was poor. Therefore, it has now been discovered that excellent thermal conductivity with increased electrical resistivity and excellent stability over a wide temperature range with time has now been obtained through the use of minor amounts of particular additives with fused magnesium oxide.

Therefore, it is an object of this invention to provide a refractory heat conductive embedding and electrical insulating composition.

Another object of this invention is to provide an improved sheathed electrical heating element having improved electrical resistivity and improved thermal conductivity.

Other objects and advantages of this invention will become apparent from the following detailed description thereof.

According to this invention, the foregoing and other objects are obtained by preparing a composition consisting of, in admixture, a major amount of fused magnesium oxide and a minor amount of a particular additive. The additive employed herein is one which is either silica,

earthalkali silicates, earth metal silicates, carbon silicates or clay, or mixtures thereof. In addition, the composition must contain less than 5 weight percent of an alkali metal salt or alkali metal oxide. It has been discovered that by employing this particular mixture to prepare a sheathed electrical heating element, the sheathed electrical heating element has improved electrical resistivity and improved thermal conductivity over sheathed electrical elements employing only fused magnesium oxide.

The following examples are set forth to illustrate more clearly the principle and practice of this invention to those skilled in the art and are not meant to be limiting in the practice thereof, and unless specified, where parts or percentages are mentioned, they are parts or percentages by weight.

EXAMPLE I

Heating elements are prepared employing separately the compositions set forth in Table I as the electrical insulating embedding material. The heating elements consist of a nickel-chrome alloy sheath, the embedding composition and a nickel-chrome alloy electrical resistance element. The embedding composition is compacted to a density of about 3.2 grams/cubic centimeter. Each element is conditioned at 1000° C. for 16 hours. The heating elements are then tested for voltage drop at 975° C. and 875° C. respectively by applying 600 volts of alternating current (60 cycles) across the electrical insulating embedding material when the total unit is at equilibrium temperature of 975° C. or 875° C. respectively. From the voltage drop measured for each element, specific impedance, in megohm-inch, is calculated. The higher the specific impedance, the better is the electrical insulating qualities of the embedding material. The results of the specific impedance so calculated are as follows:

TABLE I

	Additive	Wt. percent of additive [1]	Specific impedance (megohm-inch) 975° C.	875° C.
1	Bentonite	2.0	14.1	96.1
2	Calcined kaolinite	2.0	16.8	88.5
3	Silica (fine)	2.0	5.0	21.5
4	Zircon sand (zirconium silicate)	2.0	4.3	17.7
5	Ball clay	2.0	12.5	66.8
6	Mullite	2.0	22.3	244.3
7	Kaolin	2.0	19.5	121.7
8	Kyanite	2.0	5.3	30.7
9	Wollastonite	0.1	3.7	9.9
10	Silica (fine)	4.0	10.1	68.8
11	Coarse silica	4.0	10.1	105.4
12	Calcined coarse silica	4.0	12.2	120.6
13	Fused silica [2]	2.0	15.3	110.2
14	do [2]	4.0	36.8	207.2
15	Control (100% fused Mgo)		0.9	1.6

[1] Balance of composition is fused magnesium oxide.
[2] Fused silica is the glass or amorphous state.

EXAMPLE II

Heating elements are prepared as in Example I except that the metal for the sheath and resistance element are steel instead of nickel-chrome alloy as employed in Example I.

The insulation resistance of the embedding compositions is determined by measuring the voltage drop when applying 600 volts of alternating current (60 cycles) across the embedding composition when the total unit is at an equilibrium temperature of 975° C. The insulation resistance in megohms is then calculated from the voltage drop. The higher the insulation resistance, the

better is the electrical insulating qualities of the embedding material. The results are as follows:

TABLE II

	Additive	Wt. percent of additive [1]	Insulation resistance (megohm)
1	Bentonite	2.0	0.195
2	Silica	0.5	0.073
3	do	2.0	0.124
4	do	3.0	0.136
5	do	4.0	0.126
6	do	6.0	0.102
7	do	8.0	0.141
8	do	16.0	0.082
9	do	100.0	0.020
10	Kaolin	2.0	0.136
11	Olivine rock	2.0	0.107
12	Zircon sand (zirconium silicate)	2.0	0.071
13	Control	0.0	0.035

[1] Balance of composition is fused magnesium oxide.

This invention is directed to a granular refractory heat conductive electrical insulating composition and to a sheathed electrical heating element containing the electrical insulating composition having improved electrical resistivity while maintaining excellent thermal conductivity. The granular refractory composition disclosed herein is one which consists of a major amount of a fused magnesium oxide and a minor amount of a particular additive. The particular additive employed herein is selected from the group consisting of silica, silicates of the earthalkali, the earth metal and the carbon groups and clay, and mixtures thereof. Specifically, the granular refractory composition of this invention which can be used in sheathing electrical elements consists of in admixture 99.9–80.0 weight percent of fused magnesium oxide and, correspondingly 0.1–20.0 weight percent of the particular additive. In addition, the composition as set forth herein must be one containing less than 5 weight percent of an alkali metal salt or alkali metal oxide such as the sodium silicates, potassium silicates, potassium oxides, etc.

The magnesium oxide employed herein is a granular magnesium oxide prepared by the fusion of the raw magnesium oxide and then crushing and pulverizing the fused product into desired granular size. This material is well known in the art and is currently used in producing electrical insulating elements.

It has been discovered that by incorporating in admixture with the magnesium oxide the above-described additives, the resulting composition has greatly improved electrical insulating properties and electrical stability over a wide range of temperatures while still possessing excellent thermal conductivity. The additives which can be employed herein in place of those in the examples with essentially the same results are the silicates of the (1) pyroxene group such as enstatite and diopside, (2) amphibole group such as tremolite, (3) olivine group such as forsterite and monticellite, (4) chlorite group such as brucite, (5) andalusite group such as andalusite and sillimanite, (6) miscellaneous group such as beryl and serpentine and the clays of the kaolinite group such as kaolinite, dickite, endellite and halloysite, the Micaeous group such as muscovite, brommallite and ordovician bentonites and the Aluminous group such as gibbsite and diaspore. Other clays and silicates of the above groups are also useful including clays from other groups. The silicates useful in the practice of this invention can be classed as being derived from two types, namely, orthosilicates and metasilicates. These may combine to form polysilicates and such minerals are classified as mineral assemblages such as quaternary or ternary systems. The silica, silicates and clays of this invention may be either anhydrous or hydrated by having one or more molecules of water chemically bound up in the system.

It is interesting to note that the salts and oxides of the alkali metal group are detrimental to the practice of this invention. The salts of this group would generally be the silicates. While a small amount of such alkali

salts or oxides can be tolerated, they must nevertheless be less than 5 weight percent based on the total weight of the composition and preferably less than 3 weight percent thereof.

It is not fully understood why only silica, the particular silicates and the clays produce the phenomena so obtained herein. It is believed that in theory these particular additives undergo a phase change or transition when exposed to elevated temperatures, which phase change causes or results in a volume increase of these materials. In the case of the quartz form of silica, it has a transition temperature of 573° C. wherein α quartz converts to β quartz. The volume of β quartz is greater than the volume of α quartz. Even fused silica provides the advantages set forth above when combined with fused magnesium oxide since fused silica undergoes a phase change from the amorphous to the crystalline state when exposed to elevated temperatures. Upon further exposure to elevated temperatures, the crystalline silica undergoes the phase change as indicated previously. It is also noted that zirconia (ZrO_2) does not provide the advantages so set forth herein and this mineral decreases in volume when exposed to elevated temperatures. The above description is only in theory and is not intended to be a description or full understanding of the mechanism by which the compositions of the instant invention achieve the advantages so set forth herein.

The amount of additive employed in the composition of the instant invention ranges from about 0.1 to about 20 weight percent based upon the total weight of the composition. Above 20 weight percent, it has been noted that the electrical resistivity or impedance begins to fall off and can eventually fall below that of the straight magnesium oxide. In such a case, the advantages obtained with the additives are lost. In addition, to go below 0.1 weight percent results in virtually no advantages when employing the additive so disclosed herein.

The additive employed herein in admixture with the fused magnesium oxide may be calcined at temperatures of from 100° F. to 2700° F. before being admixed with the magnesium oxide, if so desired. It may be calcined after being admixed therewith. It may even be desirable to only combine a part of the additive either before or after being admixed with the magnesium oxide. It could exist as a mixture of any of the above. In addition, it may be desirable to use the additive as part of a composition with other inert minerals when so combined with the magnesium oxide. The important feature is that the amount of silica, silicate or clay employed be in the range of 0.1–20.0 weight percent based on the total weight of the composition.

The sheathed electrical heating element of this invention is an improvement over that of the art wherein the improvement lies in the particular electrical insulating embedding material employed. The embedding material employed in the practice of this invention is that described previously. The heating element so prepared employing the embedding composition disclosed herein is one having a greatly improved electrical resistivity, has excellent thermal conductivity and is stable over the higher temperatures. As can be seen from the values indicated in Table I and Table II, an electrical heating element prepared employing the electrical insulating embedding composition of this invention has a much greater increase in electrical insulation properties than heating elements previously known. This is surprising in that by including small amounts of the particular additive as disclosed hereinbefore results in such a great increase in the electrical resistivity. The sheathed electrical heating element can be prepared by methods commonly known today and disclosed in U.S. Pat. 2,483,839. In addition, units having a small cross-sectional area can be prepared while still having a high resistance to the passage of an electrical current.

It will thus be seen that the objects set forth above among those made apparent from the preceding descrip-

tion are efficiently attained and since certain changes may be made in carrying out the above process and in the composition set forth without departing from the scope of the invention, it is intended that all matters contained in the above description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A granular refractory, heat conductive embedding and electrical insulating composition for sheathing electrical elements, which composition consists of in admixture 99.9–80.0 weight percent of fused magnesium oxide, and correspondingly, 0.1–20.0 weight percent of an additive which is selected from the group consisting of silica, earthalkali silicates, earth metal silicates, carbon silicates and clay minerals, and mixtures thereof and which contains less than 5 weight percent of a material selected from the group consisting of an alkali metal salt and an alkali metal oxide.

2. The composition of claim **1** wherein the additive is quartz.

3. The composition of claim **1** wherein the additive is mullite.

4. An improved sheathed electrical heating element having improved electrical resistivity and excellent thermal conductivity comprising an electrical resistance element, an electrical insulating embedding composition and a metal sheath; the improvement consisting of the electrical insulating embedding material being the composition of claim **1.**

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