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COMPOSITION FOR AND PROCESS OF JOINING CORE

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This invention relates to improvements in the metal casting art and more particularly relates to a new and improved adhesive composition especially useful in the assembly of molds and cores for the preparation of metal casting-defining structures.

In recent years there has been considerable interest in metal casting molds and cores formed from sand-alkali metal silicate mixtures cured, i.e., hardened, into a casting-defining structure by carbon dioxide or other gaseous curing agent. Generally, the curing of such molds involves a chemical reaction between the gaseous curing agent, e.g., carbon dioxide, and the alkali metal silicate dispersed throughout the sand or other refractory material thereby to form a uniformly-dispersed silicon dioxide gel binder.

Despite the many advantages of such a technique, e.g., avoidance of mold or core aging and post-curing treatments heretofore considered essential, thus permitting rapid fabrication of molds and cores without requiring the use of expensive equipment while also permitting close tolerance castings, in addition to being a relatively simple process adapted to large scale operation, certain difficulties have been encountered in the process which heretofore have precluded its even wider spread application.

One of the difficulties has been the lack of a generally satisfactory means for assembling core and/or mold elements into the desired final casting-defining structure. It will be appreciated that where castings of intricate shape are to be produced, it often is essential that the mold or core elements be prepared separately and then assembled to form the desired final shape.

In this connection, the term "mold" as used throughout the specification and claims is intended to refer broadly to various types of patterns for use in the metal casting art including shell molds comprising thin-walled shell mold-forming elements in addition to a completed shell mold structure prepared by assembling two or more complementary thin-walled shell mold elements to provide a casting-defining surface therebetween. Thus it will be appreciated that the term "mold" is used in a generic sense to mean casting forms broadly as including both molds and cores.

Accordingly, the principal object of the invention is to provide a new and improved adhesive composition which facilitates assembly of molds and cores, particularly those formed using a silicate binder cured by carbon dioxide, or the like.

A further object of the invention is to provide a new and improved process for preparing such an adhesive.

A still further object of the invention is the provision of a new and improved adhesive composition.

These and other objects and advantages of the invention will appear more fully from the following description thereof.

The present invention comprises a quick-setting, high strength adhesive bond-forming composition comprising a mixture of a major proportion, i.e., greater than 50% by weight, of a liquid alkali metal silicate having a silicon dioxide:alkali metal oxide weight ratio greater than 1:1, and minor proportions, i.e., less than 50% by weight, of an aliphatic polyhydroxy compound, e.g., sorbitol, mannitol, glycerine, sugar or the like, sugar being preferred because of low cost and availability, bentonite and manganese dioxide, the latter preferably being of a low bulk density.

When the proportions of an adhesive composition in accordance with the present invention are indicated generally hereinbefore, these proportions preferably fall within the following ranges:

	Percent by weight
Aliphatic polyhydroxy compound	1 to 15
Manganese dioxide (finely-divided)	1 to 6
Bentonite	6 to 18
Liquid alkali metal silicate	60 to 92

More specifically, a preferred type of composition in accordance with this invention is the following:

	Percent by weight
Sugar (sucrose)	1 to 15
Manganese dioxide (300 mesh)	1 to 6
Bentonite (Western)	6 to 18
Liquid sodium silicate (SiO_2:Na_2O ratio greater than 1:1)	60 to 92

A specific illustrative preferred composition of this invention has the following composition:

	Percent by weight
Sugar (sucrose-cane sugar)	8.0
Manganese dioxide wad type-ground to 300 mesh	4.0
Bentonite (Western-Yellowstone)	18.0
Sodium silicate (SiO_2:Na_2O=3.22:1.0)	70.0

Other illustrative compositions of this invention are the following wherein the numbers are expressed in terms of parts by weight.

Sugar	13.5	13	340	400	30	8	13	12	8	----
Manganese dioxide	4.0	3	85	100	5	15	3	4	4	10
Bentonite	13.5	14	340	400	55	2	14	15	18	20
Sodium silicate	69.0	70	1,700	2,000	200	75	70	69	70	100
Glycerine	----	----	----	----	----	----	----	----	----	20

More specifically, an adhesive composition of the present invention comprises such a mixture wherein the manganese dioxide has a particle size of less than 300 mesh (—300 U.S. mesh). This particle size limitation in many applications is quite critical because if a larger particle size manganese dioxide is used it is observed that in the resultant mixture the manganese dioxide will not remain uniformly dispersed. Generally, while 300 mesh represents a critical definition of the maximum particle size of the low bulk density manganess dioxide, there generally is no minimum particle size, i.e., the finer the manganese dioxide particle size the better.

Referring more specifically to the manganese dioxide employed in the practice of the present invention and its criticality, it is desirable to use a manganese dioxide having the aforementioned particle size, i.e., less than 300 mesh, which is a so-called "wad" type manganese dioxide which expression refers as a field or generic term to hydrous manganese dioxide. Typical analyses, in terms

of parts by weight, of "wad" type manganese dioxide are the following:

Ingredient	A	B
K_2O	0.61	
Na_2O	0.31	1.22
CaO	1.32	6.69
MgO	0.54	0.66
BaO	9.53	0.37
CuO	0.05	
CoO	0.10	
NiO	0.10	
MnO	3.59	4.62
MnO_2	61.38	62.03
Al_2O_3	2.91	0.27
Fe_2O_3	5.86	3.59
SiO_2	3.40	
H_2O	9.85	11.21

The term "sugar" as employed in the specification and claims is intended to refer to sugar in a conventional sense as including various mono- and polysaccharides, especially mono- and disaccharides such as tetroses ($C_4H_8O_4$), pentoses ($C_5H_{10}O_5$), methyl pentoses ($C_6H_{12}O_5$), hexoses ($C_6H_{12}O_6$), polydisaccharides such as pentose-hexose ($C_{11}H_{20}O_{10}$), methyl pentose-hexose ($C_{11}H_{20}O_{10}$), as well as trisaccharides and tetrosaccharides such as 2-methyl-pentose-hexose and 3-hexose, in addition to 4-hexose. The preferred sugar is sucrose.

The term "bentonite" as used in the specification and claims is intended to refer to the mineral hydrated aluminum silicate, the main component being montmorillonite ($Al_2O_3.4SiO_2.H_2O$) or, more generally, as a clay or clay-like material which swells when wet and has strong absorbent properties. The preferred type of bentonite characterized by swelling when wet is a so-called "Western Bentonite." More specifically, bentonite is a clay mineral composed of several members of the montmorillonite group, chiefly pyrophyllite, nontranite, talc and beidellite. Bentonite conforms to the expanding crystal lattice consisting of a gibbsite sheet enclosed between two silica sheets, thus differing from kaolinite which consists of a non-expanding crystal lattice wherein one gibbsite sheet is condensed with one silica sheet. A specifically preferred bentonite is the material known as "Yellowstone Bentonite."

The liquid alkali metal silicate, i.e., an aqueous solution of an alkali metal silicate normally liquid at room temperature having a silicon dioxide:alkali metal oxide ratio greater than 1.0. While various alkali metal silicates can be used, including potassium silicates, sodium silicates, and silicates of the other alkali metals such as lithium, rubidium, cesium, it will be appreciated that sodium silicates are generally the most readily available and most economical. Accordingly, particular emphasis is made throughout the specification and claims to sodium silicates although it is to be understood that the invention is not to be so limited. It will be understood thus that the silicate is a so-called "silicious silicate," i.e., having a predominant amount of silicon dioxide as compared to a lesser proportion of alkali metal oxide. The preferred silicates are sodium silicates having a silicon dioxide:sodium oxide ratio greater than 1.0:1.0, preferably in the range from about 2.8 to 3.75:1 and a specific gravity within the range from about 40° to 43° Bé., measured at 20° C., typically preferred silicates having specific gravities of about 41.5° Bé. and about 42° Bé.

The present invention is also directed to the method of preparing the herein-described adhesive composition. Generally, the process of this invention comprises the steps of adding a minor amount of an aliphatic polyhydroxy compound, e.g., sugar, to a major proportion of a liquid alkali metal silicate until it is dissolved therein, thereafter adding the manganese dioxide to the thus-formed mixture until thoroughly and uniformly dispersed therein and subsequently adding bentonite until the desired dispersion is obtained.

While either the sugar or manganese dioxide can be added to the liquid silicate first, or, if desired, simultaneously or in admixture, it is essential that the bentonite be added last. If the bentonite is mixed directly with the silicate, and manganese dioxide and sugar added subsequently, it is found that the high adsorptive properties of the bentonite result in a drying of the silicate which results in an unsatisfactory, non-uniform mixture unsuitable for many applications.

In the following examples the reference to "test blocks" means 2-inch cubes prepared by impregnating a sand-sodium silicate mixture with carbon dioxide. The exposure to carbon dioxide cures the cube into a rigid high-strength block by converting the sodium silicate into a silicon dioxide gel uniformly dispersed throughout the sand. In order that those skilled in the art may more completely understand the present invention and the preferred methods by which the same may be carried into effect, the following specific examples are offered:

Example I

A core paste is produced by adding 40 gms. of glycerine (crude) to 200 gms. of liquid sodium silicate

(SiO_2:Na_2O=3.22:1.0, 41.5°–42.5° Bé.)

mixing until dissolved. To this mixture is added 10 gms. of manganese dioxide. After the manganese dioxide is dispersed throughout the adhesive, 40 gms. of bentonite is incorporated. This adhesive is applied to 2-inch sand-silicate (CO_2-cured) blocks and in two minutes the adhesive supports one of the blocks, in five minutes the blocks are pulled apart and the adhesive does not separate although the sand layer fractures.

Using the same adhesive, tests are made with 2-inch cubes of uncured sand-silicate mold-forming mixtures and carbon dioxide (20 p.s.i.g.) is passed through two such blocks adhesively joined using the composition of this example, the CO_2 being applied for ten seconds. Again, upon application of tension the adhesive bond does not break, although the sand fractures.

Example II

A core paste is prepared by mixing 200 gms. liquid sodium silicate (SiO_2:Na_2O=3.22:1.0, 41.5°–42.5° Bé.), 40 gms. sugar, 10 gms. manganese dioxide (wad type) and 40 gms. bentonite in this order. Substantially the same results of Example I are obtained when applied to core elements to be adhesively joined.

Example III

A core paste embodying the present invention is prepared by mixing 12 parts sugar (sucrose) with 69 parts of a liquid sodium silicate (SiO_2:Na_2O=3.22:1.0, 41.5°–42.5° Bé.), until the sugar is completely dissolved. There are then added 4 parts of manganese dioxide (African ore, —300 mesh) and, subsequently, 15 parts bentonite (Yellowstone). The resultant paste exhibits excellent adhesive properties and is a uniform dispersion.

Example IV

There is prepared a core paste embodying the present invention by mixing 4200 gms. of liquid sodium silicate (SiO_2:Na_2O=3.22:1.0, 40.0°–41.5° Bé.) and 480 gms. cane sugar until the sugar is completely dissolved. To this mixture is added 240 gms. of —300 mesh manganese dioxide and 1080 gms. Yellowstone Bentonite. The resultant mixture exhibits a high adhesive strength when applied to core elements.

It is to be understood that, although the invention has been described with specific reference to particular embodiments thereof, it is not to be so limited since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

What is claimed is:

1. An adhesive composition of matter comprising the following ingredients in about the proportions stated:

	Percent by weight
Aliphatic polyhydroxy compound	1 to 15
Manganese dioxide	1 to 6
Bentonite	6 to 18
Liquid alkali metal silicate	Balance

2. An adhesive composition of matter comprising the following ingredients in about the proportions stated:

	Percent by weight
Sugar	1 to 15
Manganese dioxide	1 to 6
Bentonite	6 to 18
Liquid alkali metal silicate	Balance

3. A composition according to claim 1 wherein the silicate is a sodium silicate.

4. A composition according to claim 1 wherein the silicate is a sodium silicate having a silicon dioxide:sodium oxide ratio greater than 1.0:1.0.

5. A composition according to claim 1 wherein the particle size of the manganese dioxide is less than 300 mesh.

6. A composition of matter comprising in admixture the following in about the proportion stated:

	Percent by weight
Sugar	1 to 15
Manganese dioxide (—300 mesh)	1 to 6
Western Bentonite	6 to 18
Liquid sodium silicate (SiO_2:Na_2O=2.8 to 3.75:1.0)	Balance

7. A composition of matter comprising in admixture the following:

	Percent by weight
Liquid sodium silicate (Na_2O:SiO_2=1:3.22)	70
Cane sugar	8
Manganese dioxide (—300 mesh)	4
Western Bentonite	18

8. A composition according to claim 7 wherein the manganese dioxide is a wad type ore.

9. A composition according to claim 7 wherein the bentonite is a Yellowstone Bentonite.

10. The method of preparing a quick-setting, adhesive composition which comprises the steps of dissolving a minor amount of an aliphatic polyhydroxy compound in a major amount of a liquid alkali metal silicate, adding to the thus-prepared mixture a minor proportion of finely-divided low bulk density manganese dioxide until thoroughly dispersed therein and thereafter dispersing bentonite therein.

11. The method according to claim 10 wherein the sugar constitutes about 1 to 15% by weight of the silicate, the manganese dioxide has a particle size smaller than 300 mesh and constitutes about 1 to 6% by weight of the silicate, and the bentonite constitutes about 6 to 18% by weight of the silicate present.

12. The method of preparing a quick-setting adhesive which comprises the steps of dissolving about 8 parts of cane sugar in about 70 parts of a liquid sodium silicate having an SiO_2:Na_2O ratio of 3.22:1.0, thereafter dispersing about 4% of —300 mesh manganese dioxide therein and subsequently dispersing in the thus-formed mixture about 18% Western Bentonite.

13. In the production of castings via the use of thin-walled rigid shell molds characterized by a fine, accurately-dimensioned, casting-defining surface, the improvement which comprises adhesively joining complementary sections of said shell mold by applying as an adhesive a composition as defined in claim 1 to at least one of said sections and thereafter placing said sections in contact with each other thereby to form a quick-setting, adherent bond and resultant unitary shell mold structure.

14. In the preparation of molds or cores for metal casting operations using as a core or mold binder an alkali metal silicate-finely-divided refractory material contacted with a gaseous hardening substance while in the desired casting-defining shape, the improvement which comprises assembling molds or core elements so prepared into a metal casting-defining structure which comprises applying a composition as defined in claim 1 as an adhesive to at least one of said sections and thereafter placing said sections in contact with each other through said adhesive whereby a quick-setting, high strength adhesive bond is effected and a unitary casting-defining structure formed thereby.

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