March 18, 1958 J. G. AFFLECK 2,827,397

WATER-PROOFING OF CONCRETE OR MASONRY SURFACES

Filed Aug. 23, 1954

FIG. 1

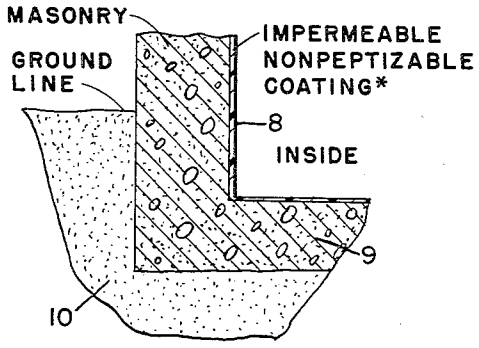



FIG. 2

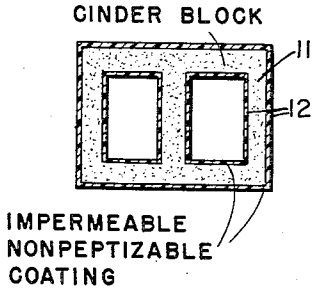



FIG. 3

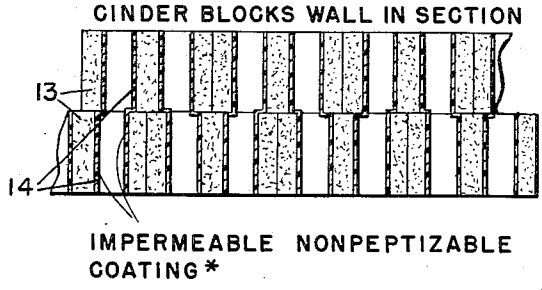



FIG. 4

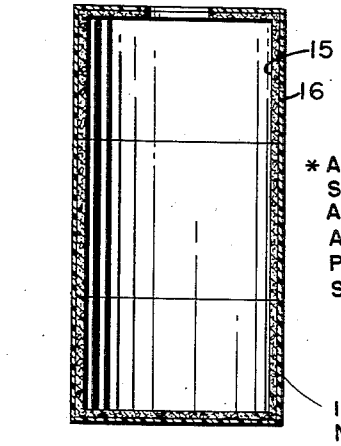



FIG. 5

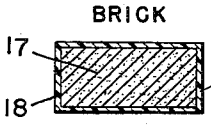
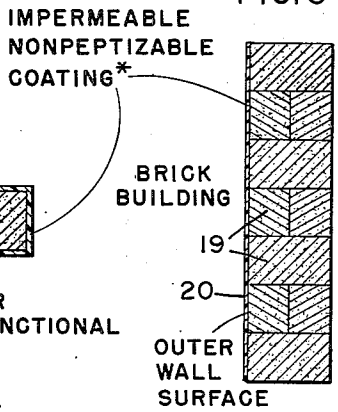



FIG. 6




* AQUEOUS COMONOMER SOLUTION OF MONOFUNCTIONAL AND POLYFUNCTIONAL ACRYLIC COMPOUNDS POLYMERIZED TO GEL STAGE IN SITU

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2,827,397

# WATER-PROOFING OF CONCRETE OR MASONRY SURFACES

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14 Claims. (Cl. 117—123)

The present invention relates to water-proofing porous masonry and the resulting water-impermeable structures.

Many proposals have been made for the water-proofing of concrete and other preformed masonry structures. For the most part these treatments have been comparatively ineffective and have often required the excavation at relatively high cost of large amounts of soil on the exterior of subsoil masonry walls in order to permit the application of heavy coatings of bituminous or other water-proofing materials. Further, no composition has yet been prepared for application to the interior side of subsoil masonry walls which reduces or eliminates the penetration of moisture to a satisfactory degree.

An object of the invention is to provide an improved preformed masonry structure.

Another object of the invention is to provide a method for rendering porous masonry substantially impermeable to liquids.

A further object of the invention is to provide an improved structure which is substantially impervious to the penetration of liquids.

Still another object of the invention is to provide an economical method for water-proofing masonry walls from the interior of the masonry structure.

Other objects and benefits of the invention will be apparent to those skilled in the art from the detailed description hereinbelow.

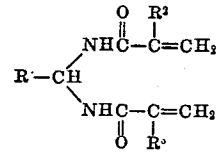
The above and other objects of the invention may be accomplished by the treatment of porous masonry, either laid in situ or preformed, including concrete, brick, stone, clay, tile, cinder blocks, mortar and other masonry joint materials, with a solution containing a monofunctional acrylic compound and a polyfunctional monomeric acrylic compound. The invention accordingly comprises a process of impregnating rigid preformed porous masonry with a solution comprising a monofunctional monomer having a single radical of the group consisting of acrylyl and methyacrylyl radicals as a major portion of the solute and a polyfunctional monomer having two or more of the same radicals as a minor portion of the solute followed by polymerizing the monomeric material in situ to a water-impermeable nonpeptizable gel and also the resulting treated masonry structure.

Suitable monofunctional acrylic compounds for use in the present invention include acrylamide, N-methylol acrylamide, acrylic acid, hydroxyethyl acrylate and the water-soluble monovalent salts of acrylic acid as exemplified by ammonium acrylate, sodium acrylate, potassium acrylate, and also by the monoamine salts of acrylic acid as exemplified by the methylamine, ethylamine and propylamine salts of the acid, as well as mixtures of any of the aforesaid substances. The corresponding methacrylic compounds are equally operative as is any other monomer containing a single acrylyl or methacrylyl radical which is substantially soluble in water, that is to the extent of at least about 3%, in order to permit its application in the desired aqueous solution. Acrylamide is the preferred monofunctional compound since



it produces excellent results and is relatively low in price.

The polyfunctional comonomer employed in the instant treatment of masonry is one containing two or more acrylyl or methacrylyl groups per molecule. Alkylidene diacrylamides or alkylidene dimethacrylamides of the type disclosed in Lundberg Patent 2,475,846 are preferred for the purpose provided that they are at least sparingly soluble in water, for instance to the extent of 0.25% by weight or more. This group of compounds is best illustrated by reference to the following general formula:



in which R'—CH< is the hydrocarbon residue of an aldehyde and $R^2$ and $R^3$ are either methyl or hydrogen.

The R'—CH< in the above formula may be the hydrocarbon residue of formaldehyde, acetaldehyde, propionaldehyde, butrylaldehyde, pentanal, crotonaldehyde, benzaldehyde, furfural, salicylaldehyde, cinnamic aldehyde, or the like. In other words, R' may be hydrogen, alkyl, alkenyl, aralkyl, aralkenyl, aryl or heterocyclic. Instead of formaldehyde itself, paraformaldehyde such as hexamethylenetetramine may be used to produce the most useful resin intermediates which are methylene bis-acrylamides.

Methylene bis-acrylamide is preferred for the purpose since it is an excellent cross-linking agent for acrylamide and other similar monofunctional compounds in the copolymerization reactions with which the present invention is concerned. However, other polyfunctional acrylyl or methacrylyl monomers of mixtures thereof may also be employed including 1,3-diacrylyl-1,3,5-hexahydrotriazine, 1,3,5-triacrylyl-1,3,5-hexahydrotriazine and the corresponding methacrylic acid derivatives, as well as the salts containing two or more acid radicals of acrylic or methacrylic acid with bivalent or other polyvalent metals as exemplified by beryllium, magnesium, calcium, strontium, barium, zinc, cadmium, copper, mercury, manganese, chromium, molybdenum, nickel, antimony, zirconium, etc., as well as the diacrylate or dimethacrylate of ethylene glycol. The preparation of these monomers is known to those skilled in the art and accordingly is not set forth herein.

The proportions of monofunctional and polyfunctional monomers are critical and the latter should range from about 0.5% to 25% and preferably between 3 and 10% of the total weight of polymerizable material. These proportions are essential in order to produce a gel polymer of the desired characteristics, that is, one which is compatible with water in the sense that a dried gel will be reactivated or swollen again by water and yet one which is impermeable to the passage through the swollen gel of any substantial quantities of water or moisture. If the amount of cross-linking between the linear chains derived from the monofunctional monomer is too small, the polymer is of an essentially linear or water-soluble nature and such polymers may be leached out of the masonry by the action of water or moisture. On the other hand too high a degree of cross-linking in the resulting resin will destroy its gel characteristics and tend to convert it to a rigid three-dimensional resin which will not swell upon rewetting. Accordingly the polyfunctional component must always be present in minor quantities relative to the monofunctional monomer.

Polymerization of the vinyl groups of the compounds used in this invention is effected with any of the usual water-soluble oxygen-containing catalysts, such as tertiary butyl hydroperoxide, the ammonium, potassium and so-

dium persulfates, hydrogen peroxide, the alkali metal and ammonium chlorates, perborates, percarbonates, and the like. It is frequently advantageous to use a redox catalyst system of oxygen-containing compound with a reducing agent, such as sodium thiosulfate, sodium or potassium bisulfite, hydroquinone, etc., a typical combination being ammonium persulfate and sodium thiosulfate. The quantity of catalyst used is not considered critical and, in general, from about 0.1% to about 20% based on the weight of polymerizable monomers may be used.

The rate of gel formation of a particular resin may vary depending upon whether polymerization is effected in the presence of acid or alkali, and this factor should also be considered in determining the polymerization conditions.

The rate of copolymerization or gel formation varies directly with both temperature and concentration of the initiator or catalyst, and the time of gelation may vary from a few minutes to 8 hours or more. In the treatment of masonry, it is often impractical to adjust the temperature; therefore, the polymerization rate is usually controlled by selection of the optimum catalyst: monomer ratio. However, the gelation time is usually of little importance and is best determined and adjusted by experiments on the actual site of operations using varying ratios of catalyst to the comonomers. It should of course be sufficiently long to permit mixing sizable batches of the monomers and catalyst on the job and application thereof to masonry surfaces without premature gelling.

In general, solutions used in the instant process have excellent wetting characteristics and will require no wetting agent to aid their penetrating deeply enough into the pores of masonry. However, where an extremely heavy treatment is required for some special purpose, it is contemplated that a suitable wetting agent such as di-2-ethylhexyl ester of sodium sulfosuccinate or other compatible wetting agent may be employed. In some instances it may be necessary to add a compatible thickening agent for economy in preventing too deep a penetration into the porous structural material. Suitable thickeners include casein, glues, gelatin, gums, and carboxymethyl cellulose. It is to be emphasized, however, that the present treatment does not amount to a mere coating of the surface, for the copolymeric gels described herein readily rub or wear off of the surfaces and therefore cannot provide the effect which is desired. The monomeric solution must penetrate into the pores of the masonry and also into any small cracks or crevices which might permit the passage of water. The pores adjacent the surface to be treated should be thoroughly impregnated or filled with the solution of comonomers which then polymerizes in situ into gel form. In general, it appears that comparatively little is to be gained by impregnating the masonry to a considerable depth and such treatments are of course more costly.

The solutions described herein may be applied in any suitable manner, as for example by spraying, brushing, or flooding the solution onto the masonry to be treated. In addition, it appears immaterial whether the impregnant is applied to the exterior or interior walls of the preformed masonry structure, as the treatments operate by forming a gel inside the pores which is compatible with water but impermeable to it. Water seepage through the masonry is checked either by the swollen gel or by the reactivation of a gel which has dried in the pores. This rewetting effect is comparatively rapid so the seepage swells the dried gel back to its original state and hence blocks the passage of any appreciable amount of water. Interior application of the treatment is a major advantage of the present process since it is usually far easier to apply the impregnant in this manner, inasmuch as it may be used in finished basements or cellars without requiring the excavation of earth from the exterior walls. However, the invention is not limited to the treatment of cellars and other underground masonry, as it is equally effective in preventing the seepage of wind-driven rain through building walls of brick, cinder blocks, or concrete, and for eliminating the seepage of water and other liquids from concrete tanks.

In practicing the present process, the total concentration of monomers in the solution may range from about 3 to about 50% or more depending on the solubilities of the particular comonomers and the acceptability of the extra expense of an extremely heavy treatment. Concentrations of about 3 to 20% are preferable for most purposes and especially good results are obtainable with solutions containing about 10% of the comonomers.

The quantity of the monomeric agents employed will, of course, vary with the porosity of the masonry undergoing treatment and the desired depth of impregnation. In general, it appears desirable to impregnate the masonry to a depth of at least about ⅛ inch and the maximum depth of impregnation appears to be limited only by economic considerations. The total quantity of monomeric agents applied may vary from about 0.005 up to about 0.5 pound per square foot of masonry being treated and even up to 3 or more pounds per square foot for special purposes in which the added cost is justified.

The present treatment appears to be capable of withstanding comparatively high water pressures inasmuch as there seems to be no tendency for the gel to peel off or otherwise to be displaced from the interior of pores of the size encountered in various types of masonry. Large crevices in the masonry should be filled with mortar in the usual fashion of making such repairs, but the novel treatment provides an adequate seal for smaller cracks.

For a better understanding of the nature and objects of the invention, reference should be had to the following examples which are intended to illustrate the invention and which all portions are given in terms of weight unless otherwise specified.

*Example I*

| | Parts by weight |
|---|---|
| Acrylamide | 95 |
| N,N'-methylene bis-acrylamide | 5 |
| Tertiary butyl hydroperoxide | 6 |
| Water | 894 |

The above monomers are dissolved in the water with stirring and the peroxide catalyst is added immediately before application to brick and to the cinder block structure mentioned below.

A common unglazed smooth building brick is sprayed on all surfaces with the above solution and then allowed to stand for 6 hours to insure complete polymerization. The treated brick, along with a similar untreated brick, is first weighed and then immersed in a in a vessel containing water at room temperature for a period of one hour. Next, both bricks are removed from the water, rubbed dry with cloths to remove surface moisture and then reweighed. The weight of the untreated brick is found to be substantially greater due to the absorption of water into its interior, whereas the treated brick displays only a negligible weight increase as a result of the immersion.

A hollow column is erected on a concrete slab to a height of approximately 50 inches by laying 6 hollow commercial 8" x 8" x 16" cinder blocks containing a center web upon one another. A conventional building mortar is used to seal the joints between the blocks and the mortar is allowed to cure thoroughly for 30 days. This structure contains 2 vertical wells or tubes and the solution described above is poured into one of these and then syphoned off in such a manner that the treating agent is in contact with the masonry for an average of about 30 minutes. The bottom of the treated well is dried with wadding attached to a handle of sufficient length and allowed to remain empty overnight. Next, both wells are filled to a depth of 4 feet with water at room temperature. After 24 hours it is observed that the surface of the column surrounding the untreated well is wet

with moisture exuding through the cinder blocks and mortar joints, but all of the areas of the cinder blocks surrounding the treated well are found to be dry.

*Example II*

| | Parts by weight |
|---|---|
| N-methylol acrylamide | 97 |
| 1,3,5-triacrylyl 1,3,5-hexahydrotriazine | 3 |
| Tertiary butyl hydroperoxide | 6 |
| Water | 1894 |

Example I is repeated using the above treating solution on fresh test specimens and similar results are obtained.

*Example III*

| | Parts by weight |
|---|---|
| Methacrylamide | 95 |
| Calcium acrylate | 5 |
| Tertiary butyl hydroxide | 6 |
| Water | 394 |

The tests described in Example I are repeated with a solution of this composition and again it is apparent that a very high degree of water-proofing is obtained with the unglazed brick and with the cinder block and mortar column.

*Example IV*

| | Parts by weight |
|---|---|
| Sodium acrylate | 95 |
| Ethylene glycol dimethacrylate | 5 |
| Tertiary butyl hydroperoxide | 6 |
| Water | 894 |

Treating and testing another cinder block well and brick according to the procedure of Example I with the above solution, it is again evident that both the brick and the cinder block well are rendered impermeable to water.

*Example V*

| | Parts by weight |
|---|---|
| Hydroxyethyl acrylate | 95 |
| Methylene bis-methacrylamide | 5 |
| Tertiary butyl hydroperoxide | 6 |
| Water | 894 |

The tests are again repeated with fresh masonry using the aqueous agent described above and again no significant increase in the weight of the treated brick or exudation of moisture onto the exterior surface of the cinder blocks surrounding the treated well are noted.

In the drawings:

Fig. 1 is a cross-sectional portion of a preformed masonry basement foundation with the polymer gel coating of the invention applied to the interior wall and floor.

Fig. 2 and Fig. 5 show a cinder block and building brick respectively in cross section with the coating applied to the surfaces.

Fig. 3 shows the coating applied to the inner well surfaces of a preformed cinder block wall.

Fig. 4 shows a concrete tank which has been coated at the outer surface by the polymer gel.

Fig. 6 shows a brick wall in cross section with the outer surface coated with the polymer gel of the invention.

In a more detailed description of the figures of the drawing, Fig. 1 shows the polymer gel coating **8** applied to the inner wall and floor of a building basement foundation **9** which is supported by and contacted at its outer adjacent surfaces by earth **10**. The foundation wall **9** as shown is poured concrete, although the coating may also be applied to other preformed basement masonry foundation construction, such as cinder block.

Fig. 2 shows a cinder block **11** which has the water impermeable coating **12** of the invention applied to the inner well surfaces and to the outer surfaces and Fig. 5 shows the coating **18** applied to an unglazed building brick **17**.

The treatment of building walls of preformed masonry is illustrated by the embodiments of Fig. 3 and Fig. 6. In Fig. 3 the coating **14** of the invention is shown applied to the inner vertical well walls formed by cinder blocks **13** and in Fig. 6 the building wall formed of bricks **19** is shown with the water impermeable coating **20** applied to the outer surface of the wall.

In Fig. 4, the water impermeable polymer gel coating **16** of the invention is shown applied to the outer surface of the concrete tank wall **15**.

While there are above disclosed but a limited number of embodiments of the process and treated article of the invention herein presented, it is possible to produce still other embodiments without departing from the inventive concept herein disclosed, and it is desired therefore that only such limitations be imposed on the appended claims as are stated therein or required by the prior art.

I claim:

1. An article which comprises porous masonry having pores containing a gel formed by the copolymerization of a major portion of monofunctional monomer having a single radical of the group consisting of acrylyl and methacrylyl radicals and a solubility in water of at least 3% by weight with between about 0.5 and about 25 percent by weight based on the total polymerizable matter of a polyfunctional monomer having at least two radicals of the group consisting of acrylyl and methacrylyl radicals and having a solubility in water of at least 0.25% by weight.

2. An article which comprises a preformed porous rigid masonry structure having pores containing a water-impermeable nonpeptizable gel formed in situ by the copolymerization of a major portion of a water-soluble monofunctional monomer having a single radical of the group consisting of acrylyl and methacrylyl radicals with between about 0.5 and about 25 percent by weight based on the total polymerizable matter of a water-soluble polyfunctional monomer having at least two radicals of the group consisting of acrylyl and methacrylyl radicals.

3. An article according to claim 2 in which the polyfunctional monomer comprises an alkylidene diacrylamide.

4. An article according to claim 2 in which the polyfunctional monomer comprises methylene bis-acrylamide.

5. An article according to claim 2 in which the copolymeric gel is formed by the polymerization of monomers comprising acrylamide and methylene bis-acrylamide.

6. An article according to claim 2 in which the copolymeric gel is formed by the polymerization of monomers comprising N-methylol acrylamide and methylene bis-acrylamide.

7. An article resistant to penetration by moisture which comprises a preformed porous rigid masonry structure having pores adjacent the surface containing at least about 0.005 pound on a dry basis per square foot of masonry surface of a water-impermeable nonpeptizable gel formed in situ by the copolymerization of a major portion of acrylamide with between about 0.5 and about 25 percent by weight based on the total polymerizable matter of methylene bis-acrylamide.

8. A process which comprises impregnating porous masonry with a solution comprising a monofunctional monomer having a single radical of the group consisting of acrylyl and methacrylyl radicals as a major portion of the solute and between about 0.5 and about 25 percent by weight based on the total polymerizable material of a polyfunctional monomer having at least two radicals of the group consisting of acrylyl and methacrylyl radicals as a minor portion of the solute, and copolymerizing the monomeric material in situ to a water-impermeable gel to seal the masonry against substantial penetration by moisture.

9. A process which comprises impregnating the pores of a preformed porous rigid masonry structure with an aqueous solution of a major portion of a water-soluble monofunctional monomer having a single radical of the group consisting of acrylyl and methacrylyl radicals and between about 0.5 and 25 percent by weight based on

the total polymerizable material of a water-soluble polyfunctional monomer having at least two radicals of the group consisting of acrylyl and methacrylyl radicals, and copolymerizing the monomeric material in situ to a water-impermeable nonpeptizable gel to seal the masonry against substantial penetration by moisture.

10. A process according to claim 9 in which the polyfunctional monomer comprises an alkylidene diacrylamide.

11. A process according to claim 9 in which the polyfunctional monomer comprises methylene bis-acrylamide.

12. A process according to claim 9 in which said monomers comprise acrylamide and methylene bis-acrylamide.

13. A process according to claim 9 in which said monomers comprise N-methiylol acrylamide and methylene bis-acrylamide.

14. A process which comprises impregnating pores adjacent the surface of a preformed porous rigid masonry structure with at least about 0.005 pound of solute per



square foot of the masonry surface in an aqueous solution comprising between about 3 and about 50 percent by weight of a solute containing a major portion of acrylamide and between about 0.5 and about 25 parts by weight of methylene bis-acrylamide per 100 parts of total polymerizable matter, and copolymerizing the monomeric material in situ to a water-impermeable nonpeptizable gel to seal the masonry against substantial penetration by moisture.

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U. S. DEPARTMENT OF COMMERCE

PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 2,827,397 March 18, 1958

James G. Affleck

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 51, strike out "in a", first occurrence; column 6, line 61, after "radicals" insert --and a solubility in water of at least 3% by weight--; line 65, after "radicals" insert --and having a solubility in water of at least 0.25% by weight--.

Signed and sealed this 20th day of May 1958.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents