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(54) Title: GLASS COMPOSITIONS HAVING HIGH KI VALUES AND FIBERS THEREFROM

(57) Abstract

A fiberizable glass composition which has a KI value > 40, while possessing acceptable processing properties such as viscosity and liquidus temperatures is provided. The glass composition processes well in the furnace with acceptably low levels of foaming and is readily fiberizable. The glass has a high boron content, a high soda content, and contains only small amounts of alumina. Further, the glass contains small amounts of barium sulfate which improves the durability of the glass fibers in use.

GLASS COMPOSITIONS HAVING HIGH KI VALUES AND FIBERS THEREFROM

TECHNICAL FIELD

The present invention relates to soda lime borosilicate glass compositions having high KI values, and fibers made from these compositions which are suitable for use as glass fiber insulation.

BACKGROUND OF THE INVENTION

Glass fiber insulation is well known and has been a commercial product for many years. Generally, the insulation is made from intertwined soda lime alumina borosilicate glass fibers which are held together with a binder. The binder may be any suitable material but quite commonly is a phenol-formaldehyde resin or a urea formaldehyde resin. These binders are well known, and a spray nozzle generally applies them to the glass fibers as hot gases attenuate the fibers from a rotating device, commonly called a spinner. A conveyer collects the binder-coated fibers in the form of a blanket or batt, and heat cures the blanket to produce the final insulation. The process produces various densities by varying the conveyor speed and the thickness of the cured insulation.

It is well established that asbestos fibers when inhaled can cause significant disease in man. Though the exact mechanism responsible for the biological activity of inhaled asbestos fibers is unknown, it is widely believed that their ability to remain in the lung for extended periods of time is an important factor. Glass fibers have not been linked to disease in man. Additionally, their durability or residence time in the lung appears much less than asbestos fibers. Despite this, certain countries such as Germany have proposed regulations for the use of glass fibers in insulation products. Glass fiber compositions meeting these proposed regulations are considered to be free of suspicion and can be used for both commercial and residential installations. The problem, however, for the manufacturer is to produce glass fibers which meet the proposed regulations and standard criteria. These glasses must be fiberizable in standard wool processes, have sufficient durability in use, and have acceptable insulating properties while still meeting the compositional requirements of the proposed regulations. The proposed German regulations require that glass fibers have a numerical index (KI) greater than or equal to 40 to be considered to be free of suspicion. This index is described by the equation:

$$KI = \Sigma (Na_2O, K_2O, CaO, MgO, BaO, B_2O_3) - 2 (Al_2O_3),$$

where the values for each oxide are reported as a number corresponding to the weight percentage of that oxide in the glass composition. This requirement places severe constraints on the compositions of the glass, especially on the levels of alumina and silica in the glass composition. While one obvious attempt to meet the requirements is to reduce the level of alumina in the glass composition, such glasses tend to have poor durabilities and are difficult or impossible to fiberize by standard processes.

Recently, a number of glasses have been reported as having improved biosolubility or biodegradability. For example, Potter, U.S. Patent No. 5,055,428, Cohen et al, U.S. Patent No. 5,108,957, Nyssen, U.S. Patent No. 5,332,698, and Bauer et al, U.S. Patent No. 5,401,693, all describe glass fibers having low alumina contents and which are taught to have improved biosolubility. Additionally, published PCT applications WO 95/31411, WO 95/32925, WO 95/32926, WO 95/32927, and WO 95/35265 and published German application DE 4417230 have reported glass compositions which are said to have increased biodegradability and also meet the requirement of a KI value of ≥ 40. However, processing and performance problems remain. Accordingly, there is still a need in this art for a glass composition which has a KI value ≥ 40, while possessing acceptable processing properties such as viscosity and liquidus temperatures as well as acceptable durability in use.

DISCLOSURE OF INVENTION

The present invention meets those needs by providing a glass composition which has a KI value ≥ 40, while possessing acceptable processing properties such as viscosity and liquidus temperatures as well as acceptable durability in use. Further, the glasses process well in the furnace with acceptably low levels of foaming. The glasses have a high boron content, a high soda content, and contain only small amounts of alumina. Further, the glasses contain small amounts, less than about 1.5% by weight, of barium sulfate ($BaSO_4$, reported as $BaO+SO_3$). The glass composition has the following ranges of major components:

Ingredient	Weight Percent
SiO_2	53.0 to 58.0
Al_2O_3	0.75 to 2.0
CaO + MgO	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to <1.0
SO_3	0 to 0.5

Standard wool processes including forming from bushings and from rotary spinners easily produce fibers from this composition. Generally, the difference (delta T) between the log 3 temperature and the liquidus temperature should be 200° F (111°C) or higher to enable easy fiber formation. Durability, as measured by fiber weight loss, is less than 5% of the total fiber weight after 24 hours of exposure to hot water. The presence of small amounts of barium oxide improves glass properties including durability, and the use of barium sulfate as a source of the barium oxide in the glass provides an inexpensive and nontoxic component.

The glasses of the present invention also have acceptable insulating properties. The glass fibers may be collected and formed into standard insulation products in the shape of wool batts using conventional processes. Wool batts made from glass fibers of the present invention have acceptable insulative values and compression (recovery) properties.

BEST MODE FOR CARRYING OUT THE INVENTION

Measurements of viscosity, liquidus and durability for a number of glasses with KI $\geq$ 40 were made using standard techniques and are reported in the Table below. Those measurements indicated a compositional region of glasses which are useful for production of glass fiber insulation. Such glasses have a numerical index (KI) of $\geq$ 40 and can be fiberized easily using conventional processes. The difference (delta T) between the log 3 temperature and the liquidus temperature is generally 200°F (111°C) or higher. Durability as shown by fiber weight loss is less than 5% of total fiber weight after 24 hours of exposure to hot water.

This range is as follows for the major components:

Ingredient	Weight Percent
SiO_2	53.0 to 58.0
Al_2O_3	0.75 to 2.0
CaO + MgO	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to <1.0
SO_3	0 to 0.5

A more preferable range for the major components is as follows:

Ingredient	Weight Percent
SiO_2	53.0 to < 57.0
Al_2O_3	0.50 to 1.5
CaO + MgO	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to 0.8
SO_3	0 to 0.5

By lowering the barium sulfate (reported as $BaO+SO_3$) content to less than about 1.5% by weight, foaming in the glass melting furnace was reduced to acceptable levels while still maintaining the benefits of barium oxide on the glass properties including better control of viscosity and liquidus temperature. Surprisingly, these levels of barium sulfate in the glass composition also have a positive effect on the durability of the glass. Further, using barium sulfate as a source of barium oxide for the glass composition lowers the cost of the glass as other sources of barium oxide such as BaO and $BaCO_3$ are more expensive and may present health issues because of their toxicity.

The glass composition may also contain less than 1% by weight of any or all of Fe_2O_3, TiO_2, or SrO. The total of all weight percentages of the components of the composition is, of course, 100%.

While PCT published applications WO 95/32925, WO 95/32926, and WO 95/32927 describe glass compositions which include barium oxide, the examples in these publications use barium oxide contents of 1.0% or greater. Further, while WO 95/32926 describes the effect of barium oxide on glass durability, the examples in that publication use greater amounts of barium oxide than the present invention. None of the publications suggests that barium sulfate may be used as an effective and inexpensive source of barium oxide in a glass composition.

Durabilities of the glasses of the present invention are shown in terms of percent fiber weight loss (% fwl) after one day (1 D) exposure to water at 205°F (96.1°C). Conventional glass compositions used in the manufacture of fiberized insulation lose up to 3.9% in 24 hours. Another important property is shown as delta T, the difference between the log 3 temperature and the liquidus temperature of the glass. A normal constraint is a delta T of 200°F (111°C). In some cases, this possibly may be lowered to 150°F (83.3°C) or 175°F (97.2°C). However, further lowering of delta T would require spinner modification to form fibers. The glass compositions shown meet this delta T of at least 200°F (111°C) constraint. Glasses with alternative compositions are suggested by the data which generally meet the criteria. All the glasses had a numerical index of 40 or higher.

TABLE 1

Ingredients	Glass No. 1	Glass No. 2
SiO_2	56.19	56.2
Al_2O_3	1.1	1.1
CaO	7.4	7.58
MgO	3.47	3.0
Na_2O	18.0	18.0
K_2O	0.48	0.48
B_2O	12.28	12.56
Fe_2O_3	0.14	0.14
BaO	0.7	0.7
TiO_2	0.049	0.049
SO_3	0.14	0.14
SrO	0.048	0.048
Log 3 viscosity (°F)	1680 (915.6°C)	1679 (915.0°C)
Liquidus (°F)	1391 (755.0°C)	1417 (769.4°C)
KI	40.13	40.12

delta T	289 (160.6°C)	262 (145.6°C)
Durability (%)		
fwl after one day*	4.82 ±0.11	4.63±0.30

* Exposure to water at 205°F (96.1°C)

While certain representative embodiments and details have been shown for purposes of illustrating the invention, it will be apparent to those skilled in the art that various changes in the embodiments and features disclosed herein may be made without departing from the scope of the invention, which is defined in the appended claims.

The Claims defining the invention are as follows:

1. A fiberizable glass composition suitable for insulation consisting essentially of:

Ingredient	Weight Percent
SiO_2	53.0 to 58.0
Al_2O_3	0.75 to 2.0
CaO + MgO	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to <1.0
SO_3	greater than 0 to 0.5

wherein the glass composition has a KI value equal to or greater than 40, and barium sulfate is used as a source of said BaO in said glass composition.

2. A fiberizable glass composition as claimed in claim 1 wherein SiO_2 is present in the range of from 53.0 to less than 57.0 percent by weight.

3. A fiberizable glass composition as claimed in claim 1 wherein Al_2O_3 is present in the range of from 0.75 to 1.5 percent by weight.

4. A fiberizable glass composition as claimed in claim 1 wherein BaO is present in the range of from 0.5 to 0.8 percent by weight.

5. A fiberizable glass composition as claimed in claim 1 wherein said composition consists essentially of:

Ingredient	Weight Percent
SiO_2	56.19
Al_2O_3	1.1
CaO + MgO	10.87
$Na_2O + K_2O$	18.48
B_2O_3	12.28
BaO	0.7
SO_3	0.14.

6. A fiberizable glass composition as claimed in claim 1 wherein said composition consists essentially of:

Ingredient	Weight Percent
SiO_2	56.2
Al_2O_3	1.1
CaO + MgO	10.58
$Na_2O + K_2O$	18.48
B_2O_3	12.56
BaO	0.7
SO_3	0.14.

7. A fiberizable glass composition as claimed in claim 1 wherein said composition also includes less than 1% by weight of any or all of Fe_2O_3, TiO_2, or SrO.

8. Glass fiber insulation comprising soda lime borosilicate glass fibers having a glass composition consisting essentially of:

Ingredient	Weight Percent
SiO_2	53.0 to 58.0
Al_2O_3	0.75 to 2.0
CaO + MgO	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to <1.0
SO_3	greater than 0 to 0.5

wherein the glass compositions have a KI value equal to or greater than 40, and barium sulfate is used as a source of said BaO in said glass composition.

9. A fiberizable glass composition as claimed in claim 8 wherein said composition also includes less than 1% by weight of any or all of Fe_2O_3, TiO_2, or SrO.

10. A process for the preparation of a fiberizable glass composition suitable for insulation comprising the steps of providing a fiberizable glass composition consisting essentially of:

Ingredient	Weight Percent
SiO_2	53.0 to 58.0
Al_2O_3	0.75 to 2.0
$CaO + MgO$	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to <1.0
SO_3	greater than 0 to 0.5

wherein the glass composition has a KI value equal to or greater than 40, and barium sulfate is used as a source of said BaO in said glass composition, heating said composition to melt in, and fiberizing said glass composition.

11. A process as claimed in claim 10 wherein said glass composition also includes less than 1% by weight of any or all of Fe_2O_3, TiO_2, or SrO.

12. A fiberizable glass composition as claimed in claim 1 wherein the glass composition has a durability of less than 5% fiber weight loss based on a total fiber weight after 24 hours of exposure to hot water.

13. A fiberizable glass composition as claimed in claim 1 wherein the glass composition has a log 3 temperature and a liquidus temperature differing by at least 200°F.

14. A glass fiber insulation as claimed in claim 8 wherein the glass composition has a durability of less than 5% fiber weight loss based on the total fiber weight after 24 hours of exposure to hot water.

15. A glass fiber insulation as claimed in claim 8 wherein the glass composition has a log 3 temperature and a liquidus temperature differing by at least 200°F.

16. A fiberizable glass composition comprising:

Ingredient	Weight Percent
SiO_2	53.0 to 58.0
Al_2O_3	0.75 to 2.0
$CaO + MgO$	6.0 to 14.0
$Na_2O + K_2O$	14.0 to 22.0
B_2O_3	10.0 to 14.0
BaO	0.5 to <1.0
SO_3	greater than 0 to 0.5

wherein the glass composition has a KI value equal to or greater than 40 and barium sulfate is used as a source of said BaO in said composition.

17. A fiberizable glass composition as claimed in claim 16 wherein SiO_2 is present in the range of from 53.0 to less than 57.0 percent by weight.

18. A fiberizable glass composition as claimed in claim 16 wherein Al_2O_3 is present in the range of from 0.75 to 1.5 percent by weight.

19. A fiberizable glass composition as claimed in claim 16 wherein BaO is present in the range of from 0.5 to 0.8 percent by weight.

20. A fiberizable glass composition as claimed in claim 16 wherein said composition also includes less than 1% by weight of any or all of Fe_2O_3, TiO_2, or SrO.

21. A fiberizable glass composition as claimed in claim 16 wherein the glass composition has a durability of less than 5% fiber weight loss based on a total fiber weight after 24 hours of exposure to hot water.

22. A fiberizable glass composition as claimed in claim 21 wherein the glass composition has a log 3 temperature and a liquidus temperature differing by at least 150°F.

23. A fiberizable glass composition as claimed in claim 22 wherein the glass composition has a log 3 temperature and a liquidus temperature differing by at least 200°F.

24. A fiberizable glass composition as claimed in claim 16 wherein the glass composition has a log 3 temperature and a liquidus temperature differing by at least 200°F.

DATED this 3rd day of May, 2000.

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