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# INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5:

C03C 3/095, 3/087, 4/08

(11) International Publication Number: WO 91/11402

(43) International Publication Date: 8 August 1991 (08.08.91)

(21) International Application Number: PCT/US91/00624

(22) International Filing Date: 30 January 1991 (30.01.91)

(30) Priority data: 472,593 30 January 1990 (30.01.90) US

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(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB (European patent), GR (European patent), HU, IT (European patent), KR, LU (European patent), NL (European patent), SE (European patent), SU.

### **Published**

With international search report.

(54) Title: BATCH COMPOSITION FOR MAKING INFRARED AND ULTRAVIOLET RADIATION ABSORBING GREEN GLASS

# (57) Abstract

An infrared energy and ultraviolet radiation absorbing green-colored high total iron containing soda-lime-silica glass batch includes typical soda-lime-silica glass batch ingredients, an ultraviolet radiation absorbing quantity of a cerium containing compound, a high amount of total iron, and a surprisingly small amount of carbon which eliminates silica scum formation in the melt and silica inclusion faults in the finished glass.

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# Description

BATCH COMPOSITION FOR MAKING INFRARED AND UDTRAVIOLET RADIATION ABSORBING GREEN GLASS

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### Field off the Invention

The present invention relates generally to a glass batch composition for making infrared and ultraviolet radiation absorbing green glass.

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# Background of the Invention

It: iis generally known to manufacture infrared radiation ..... absmobing soda-lime-silica glass by the incorporation therein of iron. The iron is generally present in the glass as both fermous oxide (FeO) and ferric oxide (Fe2O3). The total amount off iron and the balance between ferrous and ferric oxides, has a direct and material effect on the color and transmittance properties of the glass. As the ferrous oxide content is increased (at the expense of the chemically reduced ferric oxide), the infrared absorption increases and 20 the ultravionet absorption decreases. The shift toward a higher concentration of FeO in relation to FeoO3 also causes a change im the color of the glass from a yellow or yellowgreen to a darker green or blue-green, which reduces the vissible transmittance of the glass. Therefore, in order to - 25 obtain greater infrared absorption in glass, without sarrificing visual transmittance, it has been deemed necessary in the prior art to produce glass with a low total irmn content which is highly reduced from Fe203 to Fe0. A low totall iron content glass is generally regarded as one having less than 0.75% by weight iron. As an example, U.S. Patent No. 3,652,303 discloses an infrared absorbing blue coloned soda-lime-silica glass composition having a visible light tramsmittance greater than 70% at one quarter inch thickness, wherein at least 80% of the low total iron content in the glass is maintained in the ferrous state by the

inclusion of a reducing quantity of tin metal or stannous chloride in the melt.

Many iron containing glass compositions additionally contain well known adjuvants such as titanium dioxide, molybdenum dioxide, and ceric oxide, for the purpose of providing ultraviolet energy absorption. These known ultraviolet energy absorbers have particular disadvantages, especially in the manufacture of automotive glazings, in that they cause the color of the glass to shift from a desirable 10 green or blue-green to an unacceptable yellow color. Ceric oxide may be added, however, at a low enough concentration so as not to adversely affect the desirable green or blue-green. color of such a glass.

- U.S. Patent No. 1,936,231 discloses a colorless glass, wherein ferric oxide is added as an ultraviolet cut-off agent in quantities so small that the resultant glass retains its high visible light transmittance. The suggested total iron content is approximately 0.35% by weight. The patent further discloses that cerium compounds may be added in small 20 quantities, as ultraviolet radiation cut-off agents, to low total iron containing glass compositions. resultant glass compositions retain their colorless appearance and high visible light transmittance properties.
- U.S. Patent No. 4,792,536 discloses a process for 25 producing an infrared energy absorbing glass, containing a low total iron concentration which is highly reduced to FeO. It is further disclosed that the infrared energy absorption can be increased by including greater amounts of total iron in the glass composition, but states that the visible light 30 transmittance would thereby be reduced below levels considered adequate for automotive glazings. The disclosed process utilizes a two stage melting and refining operation, which provides highly reducing conditions so as to increase the amount of iron in the ferrous state, for a given low 35 total iron concentration of from 0.45% to 0.65% by weight. The patent teaches that the iron must be at least 35% reduced

to FeO. Most preferably, greater than 50% of the total iron content must be reduced to the ferrous state. It is further disclosed that 0.25% to 0.5% by weight of ceric oxide may be added to the low total concentration, highly reduced iron containing glass, for the purpose of absorbing ultraviolet radiation. It is disclosed that higher concentrations of ceric oxide are to be avoided, as they would compromise the overall transmittance properties of the glass. As an example of the glass which may be produced by the process taught in 10 U.S. Patent No. 4,792,536, Composition 11 discloses a low total iron containing glass, which is 30% reduced to FeO, and contains 1% ceric oxide. At a thickness of 4 mm, the total solar energy transmittance is about 52%, and the ultraviolet radiation transmittance is about 37%. The relatively high total solar energy transmittance value results from the low total iron concentration, while the relatively high ultraviolet radiation transmittance value is caused by the low concentration of Fe<sub>2</sub>O<sub>3</sub>, a large portion of which has been reduced to FeO.

The total iron content in a glass composition is generally expressed as weight percent total Fe203, which is the sum of weight percent ferric oxide and weight percent ferric oxide equivalent of ferrous oxide, and references to total iron in this specification and claims are in accordance 25 with this convention and refer to total iron expressed as ferric oxide. When Fe<sub>2</sub>O<sub>3</sub> is added to a glass batch composition, a portion of the Fe<sub>2</sub>O<sub>3</sub> is reduced in the melt to FeO. The balance between ferrous and ferric oxides in the melt is a result of the oxidation-reduction equilibrium, and 30 is expressed hereinafter as the "ferrous value" which is defined as weight percent ferrous oxide divided by weight percent total ferric oxide.

Ceric oxide is a powerful oxidizer, and when added to an iron containing soda-lime-silica glass batch composition, greatly affects the balance between ferrous oxide and ferric oxide. Carbon may be added to the glass batch, to compensate for the oxidizing effect of the ceric oxide. However, high amounts of carbon have a detrimental effect on the batch melting process, as carbon preferentially reacts with batch sulfates such as salt cake or gypsum which are standard additives to soda-lime-silica glasses to accelerate silica dissolution and also act as fining agents. Thus, excessive carbon is known to cause silica scum formation during the melting of the batch and silica inclusion faults in the finished glass product.

10 It is known that, in order to maintain the ratio of FeO to Fe2O3 and therefore the green color of the glass, the amount of carbon required to counteract the oxidizing effect of about one weight percent of ceric oxide in a typical low total iron containing soda-lime-silica glass produced by the float glass process is generally in the range of 0.9 pounds of carbon per 1,000 pounds of glass. This level of carbon, however, interferes with the "silica wetting" action of the salt cake or gypsum, and thereby results in silica scum formation during the melting process and silica inclusion faults in the final product, as discussed hereinabove.

In order to maintain a constant ratio of FeO to Fe2O3, i.e. ferrous value, while counteracting the oxidizing effect of a constant amount of ceric oxide, as the iron content of soda-lime-silica glass is increased to that of a high iron 25 containing glass, e.g., to about 0.8% total iron, it is predicted either that the same amount of carbon must be added because the ceric oxide level is constant, or that the carbon requirement will be even greater because the equilibrium ferrous value decreases with increased iron addition, as 30 disclosed in N. E. Densem and W. E. S. Turner, "The Equilibrium Between Ferrous and Ferric Oxides in Glasses", Journal of the Society of Glass Technology, vol. XXII, no. 914, Dec. 1938, pp. 372-389. Thus, it is predicted that a batch composition for producing a green-colored glass having 35 high infrared energy absorption due to an FeO concentration (from the partial decomposition of Fe<sub>2</sub>O<sub>3</sub> in the high total

iron containing batch), and high ultraviolet radiation absorption partially due to a high concentration of ceric oxide (which is not so high as to cause the glass to appear yellow) and partially due to the large amount of Fe203 which 5 remains in the higher oxidized state, will suffer from silica scum formation during melting and result in glass having silica inclusion faults, due to excessive carbon addition.

It would be desirable to produce a green-colored glass, utilizing conventional float glass technology, for use in auto-motive and architectural glazings, having a high Illuminant A visible light transmittance of at least 70%, a low total solar energy transmittance of less than about 46%, and a low ultraviolet radiation transmittance of less than about 34%, at a glass thickness of 4 mm. The prior art suggests that such a glass composition, employing a high iron concentration and about 1% ceric oxide, can only be produced by including a large amount of carbon in the melt, resulting in silica scum formation and silica inclusion faults in the final product.

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### Summary of the Invention

It has surprisingly been discovered that the balanced redox reaction between ferrous and ferric iron, ceric oxide, and carbon in a soda-lime-silica float glass melt, shifts to a more reduced state when total iron content is increased from a low to a high total iron concentration, e.g., from about 0.5% iron to about 0.8% iron. Thus, the ferrous value increases, rather than decreases as suggested by the prior Therefore, in order to shift the redox reaction so as 30 to obtain the same ferrous value manifested at the low total iron concentration, the quantity of carbon added to the melt having a high total iron content must be reduced, contrary to the wisdom of the prior art.

Less carbon, therefore, is required in a high total iron 35 containing soda-lime-silica float glass melt, than that used in a low total iron containing melt, at a constant

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concentration of ceric oxide, in order to maintain a specific ferrous value. Carbon addition may be reduced from about 0.9 pounds to about 0.35 pounds per 1,000 pounds of glass, when the total iron concentration is increased from about 0.5% to 5 about 0.8% by weight, at a constant ferrous value of about 25% and a constant ceric oxide concentration of about 1% by weight. This lower amount of added carbon eliminates the problem of silica scum formation during melting, and likewise eliminates the formation of silica inclusion faults in the final product.

# Statement of the Invention

In accordance with the present invention, there is provided a glass batch composition for producing an infrared energy and ultraviolet radiation absorbing green-colored glass, the glass having a ferrous value from about 22% to about 29%, comprising: A) a soda-lime-silica float glass batch mixture; B) an ultraviolet radiation absorbing quantity of a cerium containing compound, in an amount which does not substantially affect the color of the glass; C) an amount of iron so as to result in at least 0.75 weight percent total iron in the glass; and D) a quantity of carbon, which is less than the amount of carbon required to achieve the same ferrous value in a glass produced from a glass batch 25 comprising ingredients A, B, and an amount of iron so as to result in 0.5 weight percent total iron in the glass.

Also, in accordance with the present invention, there is provided a process for melting an infrared energy and ultraviolet radiation absorbing green-colored soda-limesilica glass composition, the composition when melted having a ferrous value from about 22% to about 29%, characterized by admixing and heating: A) a soda-lime-silica float glass batch mixture; B) an ultraviolet radiation absorbing quantity of a cerium containing compound, in an amount which does not substantially affect the color of the glass; C) an amount of iron so as to result in at least 0.75 weight percent total

iron in the glass; and D) a quantity of carbon, which is less than the amount of carbon required to achieve the same ferrous value in a glass produced from a glass batch composition comprising ingredients A, B, and a lesser amount of iron than recited in C; thereby avoiding the formation of silica scum on the surface of the melt in an amount sufficient to have a deleterious effect on the quality of glass formed by the float process.

The batch composition of the invention may be melted and formed into a 4 mm thick glass article having an Illuminant A visible light transmittance greater than 70%, a total solar energy transmittance less than about 46%, and an ultraviolet radiation transmittance less than about 34%.

Total solar energy transmittance is a measure of energy transmittance over all solar energy wavelengths (ASTM E 424A), and is an integrated value representing the area under the transmittance versus wavelength curve for both visible and infrared wavelengths.

The batch compositions of the present invention are
20 particularly suited for the production of infrared and
ultraviolet radiation absorbing green-colored automotive and
architectural glazings by the float glass process.

# Detailed Description of the Preferred Embodiment

25 For use as an automotive windshield, infrared energy and ultraviolet radiation absorbing glass must meet federal specifications which require an Illuminant A visible light transmittance greater than 70%. The thinner glasses used in modern automobiles have made it easier to achieve the 70% 30 Illuminant A standard, but have also resulted in increased infrared energy and ultraviolet radiation transmittances. Consequently, automobile manufacturers have been forced to compensate for greater heat loads by appropriately sizing air conditioning equipment, and compelled to include more 35 ultraviolet radiation stabilizers in fabrics and interior plastic components in order to prevent their degradation.

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It is generally known in the art to produce a low total concentration highly reduced iron containing glass, having a high visible light transmittance and low infrared energy transmittance, by the float glass process. Cerium compounds 5 are known to reduce the ultraviolet radiation transmittance of such glasses. However, the amount of carbonaceous reducing agent required for preparing such glasses has made their manufacture difficult, as the carbon preferentially reacts with the salt cake or gypsum fining agent to cause a 10 silica rich layer (silica scum) to form on the top of the melt. Additionally, the glass products produced by such a process suffer from silica inclusion faults, making the products unfit for automotive or architectural glazings.

It has surprisingly been discovered that a high total iron containing glass, having high visible light transmittance and low infrared energy and ultraviolet radiation transmittances, may be prepared by melting together typical soda-lime-silica batch ingredients, and including a high amount of total iron, i.e., at least 0.75 weight 20 percent, a quantity of a cerium containing compound, and an unexpectedly small amount of carbon. The small amount of carbon, which is contrary to the teaching of the prior art, results in the elimination of silica scum formation during the melting of the batch composition, and the formation of silica inclusion faults in the finished glass product. 25 Alternatively, the quantity of a cerium containing compound may be replaced by a lesser quantity of a mixture of a cerium containing compound and titanium dioxide, resulting in an even lower required amount of carbon.

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Suitable batch ingredients, according to the present invention, which are compounded by conventional glass batch ingredient mixing devices, include sand, limestone, dolomite, soda ash, rouge, carbon, salt cake or gypsum, and a cerium containing compound, and optionally titanium dioxide. materials are conveniently melted together in a conventional float glass tank, to form a green-colored infrared energy and

ultraviolet radiation absorbing glass composition, which thereafter may be continuously cast onto the molten metal bath of a float process. The flat glass thus produced may be formed into architectural glazings, or cut and formed, such as for example by press bending, into automotive glazings.

Soda-lime-silica float glass batch mixtures are well known in the art of glass making. A typical soda-lime-silica float glass batch mixture comprises:

	Sand	1,000 <u>+</u> 200 pounds
10	Soda Ash	330 <u>+</u> 50 pounds
	Dolomite	250 <u>+</u> 50 pounds
	Limestone	70 <u>+</u> 50 pounds
	Sulfate	$12 \pm 8$ pounds

The sulfate may be for example salt cake or gypsum. This 15 batch yields approximately 1,400 pounds of glass after melting and fining in a float glass facility.

A cerium containing compound is added to the batch composition to impart ultraviolet radiation absorbency to the 20 ultimately produced glass product. The cerium containing compound is added in an amount great enough to effectively absorb ultraviolet radiation, but less than an amount which would otherwise substantially affect the color of the glass by causing a yellowish tinge. Suitable cerium containing 25 compounds include, but are not limited to, cerous carbonate, ceric oxide, cerous oxalate, ceric hydrate, and the like. A preferred cerium containing compound is cerous carbonate, and is generally added to the batch composition so as to result in a ceric oxide concentration from about 0.2% to about 1.4% and more particularly from about 0.8% to about 1.2% by weight of the glass. A preferred ceric oxide concentration is about 1% by weight. Alternatively, a mixture of a cerium containing compound and titanium dioxide may be added in place of the aforementioned amount of a cerium containing compound alone, so as to result in a concentration from about 0.1 to about 1.36 weight percent CeO2 and from about 0.02 to about 0.85 weight percent TiO2, preferably from about 0.5 to about 0.6 weight percent CeO2 and from about 0.15 to about

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0.25 weight percent  $TiO_2$  in the glass. The mixture of the ceric oxide and titanium dioxide in the glass has the same operability and utility as the greater required amount of ceric oxide alone.

Iron is added to the batch composition, typically as Fe<sub>2</sub>O<sub>3</sub>, iron oxalate, metallic iron, or the like. When the batch composition is melted in the float glass tank, the redox reaction between the iron, cerium containing compound, and carbon results in the reduction of a portion of the  $Fe_2O_3$ 10 to FeO, until an equilibrium ferrous value is established. Thus, the iron is added to the batch composition so as to produce a high total iron concentration of at least 0.75%, generally 0.75% to 1.1% or 1.2%. In a preferred embodiment, the total iron content is from 0.75% to about 0.9% by weight 15 of the glass. Most preferably, the concentration is from 0.75% to about 0.85% by weight of the glass. The ferrous value, which imparts the green color to the high total iron containing glass produced from the batch compositions of the present invention, is generally from about 22% to about 29%. 20 Preferably, the ferrous value is from about 24% to about 27%.

It is generally known that the amount of carbon which must be added to a low total iron containing soda-limesilica float glass melt, i.e., a batch composition for producing a glass containing about 0.5% by weight total iron and about 1% by weight ceric oxide, is in the range of about 0.9 pounds of carbon per 1,000 pounds of glass, in order to produce a green-colored glass. However, the amount of carbon which must be added to a high total iron containing sodalime-silica float glass melt, which additionally contains a cerium containing compound so as to produce a glass containing about 1% by weight ceric oxide, according to the present invention, is surprisingly less than the amount required for the aforementioned low total iron containing The range of carbon required for the batch compositions of the present invention is generally from about 0.15 to about 0.7 pounds per 1,000 pounds of glass,

and most often from about 0.15 to about 0.5 pounds per 1,000 pounds of glass, to produce a green-colored glass having a ferrous value from about 22% to about 29%. By the term "carbon" as used herein is also meant other carbonaceous

5 materials generally known as providing carbon for glass batches, such as for example sea coal, wood flour, etc.

More specifically, the amount of carbon required when using a cerium containing compound alone is from about 0.3 to about 0.5 pounds per 1,000 pounds of glass, and the amount of

10 carbon required when using a cerium containing compound in combination with titanium dioxide is generally from about 0.15 to about 0.45 pounds per 1,000 pounds of glass, and most often from about 0.15 to about 0.15 to about 0.3 pounds per 1,000 pounds of glass.

The batch compositions of the present invention, when charged to a float glass facility, produce green-colored glass having an Illuminant A visible light transmittance greater than 70%, a total solar energy transmittance less than about 46%, and an ultraviolet radiation transmittance less than about 34%, at a glass thickness of 4 mm. The green color is characterized by an Illuminant C dominant wavelength from about 498 nm to about 540 or 550 nm, preferably about 498 to about 518 nm, and a color purity from about 2% to about 4%, preferably about 2% to about 3%.

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#### Examples 1-9

Various amounts of rouge, cerous carbonate, titanium dioxide and carbon are added to a typical soda-lime-silica float glass batch mixture comprising:

30	Sand	1,000	pounds
	Soda Ash	326	pounds
	Dolomite	248	pounds
	Limestone	67	pounds
	Salt Cake	8	pounds

The amounts of rouge, cerous carbonate, titanium dioxide and carbon added are as follows:

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Table I Glass Batch Ingredients

			Cerous				Pounds Carbon
5			Carbonate	$TiO_2$	Rouge	Carbon	per 1,000
			(pounds)	(pounds)	(pounds)	(pounds)	<u>Pounds Glass</u>
	Example	1	24	- 0 -	11.5	0.42	0.30
	Example	2	24	-0-	11.5	0.49	0.35
	Example	3	24	- 0 -	11.5	0.56	0.40
10	Example	4	24 .	-0-	11.5	0.63	0.45
	Example	5	24	<del>-</del> 0 -	11.5	0,63	0.45
	Example	6	24	- 0 -	11.5	0.70	0.50
	Example	7	16	4.2	14.5	0.63	0.45
	Example	8	16	4.2	14.5	0.63	0.45
15	Example	9	24	-0-	14.5	0.98	0.70

Silica scum does not form during the melting of the aforementioned batch ingredients, and silica inclusion faults are not observed in the resultant glass.

The properties of the resultant glasses at a thickness 20 of 4 mm are as follows:

Table II

		<u>Ex. 1</u>	<u>Ex. 2</u>	<u>Ex. 3</u>	<u>Ex. 4</u>	<u>Ex.5</u>
25	Glass Thickness	4 mm	4 mm	4 mm	4 mm	4 mm
	Total Iron, as Fe <sub>2</sub> 0 <sub>3</sub> (%)	. 782	.789	.783	.788	.788
30	CeO <sub>2</sub> (%)	.913	.909	.915	.914	.913
	Ferrous Value (%)	25.1	25.7	26.2	27.3	27.5
2.5	Illuminant A (%)	72.8	72.3	72.2	71.2	71.5
35	Total Solar Transmittance (%)	45.9	45.1	44.8	43.9	43.7
40	UV Transmittance (%)	33.0	33.2	33.3	33.5	33.5
	Illuminant C Domi- nant Wavelength (nm)	512.8	509.2	508.2	505.2	504.5
45	Color Purity (%)	2.4	2.4	2.5	2.8	2.9

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Table II (Cont.)

		<u>Ex. 6</u> <u>I</u>	Ex. 7	<u>Ex. 8</u>	Ex: 9
5	Glass Thickness	4 mm	3.4 mm	3.2 mm	3.2 mm
	Total Iron, as Fe <sub>2</sub> O <sub>3</sub> (%)	.784	.981	.994	994
10	CeO <sub>2</sub> (%)	.911	. 596	.584	.93
	TiO <sub>2</sub> (%)	-0	. 294	.284	- 0 -
1.5	Ferrous Value (%)	27.7	25.4	25.4	25.4
15	Illuminant A (%)	71.6	70.5	71.4	71.4 .
20	Total Solar Transmittance (%)	43.6	43.3	44.6	44.7
20	UV Transmittance (%)	33.6	29.3	30.9	33.2
2.5	Illuminant C Dominant Wavelength (nm)	504.6	537.5	534.8	510.0
23	Color Purity (%)	2.9	3.5	3.1	2.8

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#### WHAT IS CLAIMED IS:

- 1. A glass batch composition, for producing an infrared energy and ultraviolet radiation absorbing green-colored glass, the glass having a ferrous value from about 22% to about 29%, comprising:
  - A) a soda-lime-silica float glass batch mixture;
  - B) an ultraviolet radiation absorbing quantity of a cerium containing compound, in an amount which does not substantially affect the color of the glass;
  - C) an amount of iron so as to result in at least 0.75 weight percent total iron in the glass; and
  - D) a quantity of carbon, which is less than the amount of carbon required to achieve the same ferrous value in a glass produced from a glass batch comprising ingredients A, B, and an amount of iron so as to result in 0.5 weight percent total iron in the glass.
- 2. The glass batch composition according to claim 1, wherein said soda-lime-silica float glass batch mixture 20 comprises:
  - A)  $1,000 \pm 200$  pounds of sand;
  - B)  $330 \pm 50$  pounds of soda ash;
  - c)  $250 \pm 50$  pounds of dolomite;
  - D)  $70 \pm 50$  pounds of limestone; and
- E) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum.
- 3. The glass batch composition according to claim 1, wherein said cerium containing compound is selected from the group consisting of cerous carbonate, ceric oxide, cerous oxalate and ceric hydrate.
  - 4. The glass batch composition according to claim 3, wherein said cerium containing compound is cerous carbonate.

5. The glass batch composition according to claim 1, wherein said cerium containing compound is added so as to result in a concentration of cerium oxide in the glass from about 0.8% to about 1.2% by weight.

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6. The glass batch composition according to claim 1, wherein said iron is added so as to result in a concentration of total iron in the glass from 0.75% to about 0.9% by weight.

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7. The glass batch composition according to claim 6, wherein said iron is added so as to result in a concentration of total iron in the glass from 0.75% to about 0.85% by weight.

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- 8. The glass batch composition according to claim 1, wherein the ferrous value in the glass is from about 24% to about 27%.
- 9. The glass batch composition according to claim 1, wherein said carbon is from about 0.15 pounds to about 0.5 pounds per 1,000 pounds of glass.
- 10. The glass batch composition according to claim 1,
  25 further comprising a quantity of titanium dioxide, wherein
  the resultant glass contains from about 0.5 to about 0.6
  weight percent CeO<sub>2</sub> and from about 0.15 to about 0.25 weight
  percent TiO<sub>2</sub>.

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- 11. A glass batch composition, for producing infrared energy and ultraviolet radiation absorbing green-colored glass, the glass having a ferrous value from about 24% to about 27%, comprising:
  - A) a soda-lime-silica float glass batch mixture, comprising:
    - i)  $1,000 \pm 400$  pounds of sand;
    - ii) 330  $\pm$  50 pounds of soda ash;
    - iii)  $250 \pm 50$  pounds of dolomite;
    - iv) 70  $\pm$  50 pounds of limestone; and
    - v) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum;
    - B) an ultraviolet radiation absorbing quantity of a cerium containing compound selected from the group consisting of cerous carbonate, ceric oxide, cerous oxalate, and ceric hydrate, in an amount which does not substantially affect the color of the glass;
    - C) an amount of iron so as to result in a concentration of total iron in the glass from 0.75% to about 0.9% by weight; and
    - D) a quantity of carbon, which is less than the amount of carbon required to achieve the same ferrous value in a glass produced from a glass batch comprising ingredients A, B, and an amount of iron so as to result in 0.5 weight percent total iron in the glass.
- 12. The glass batch composition according to claim 11, wherein said cerium containing compound is cerous carbonate.
- 30 13. The glass batch composition according to claim 11, wherein said cerium containing compound is added so as to result in a concentration of cerium oxide in the glass from about 0.8% to about 1.2% by weight.

14. The glass batch composition according to claim 11, wherein said iron is added so as to result in a concentration of total iron in the glass from 0.75% to about 0.85% by weight.

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15. The glass batch composition according to claim 11, wherein said carbon is from about 0.15 pounds to about 0.5 pounds per 1,000 pounds of glass.

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16. The glass batch composition according to claim 11, further comprising a quantity of titanium dioxide, wherein the resultant glass contains from about 0.5 to about 0.6 weight percent  $CeO_2$  and from about 0.15 to about 0.25 weight percent  $TiO_2$ .

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17. A glass batch composition, for producing an infrared energy and radiation absorbing green-colored glass, the glass having a ferrous value from about 24% to about 27%, comprising:

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- A) a soda-lime-silica float glass batch mixture, comprising:
  - i)  $1,000 \pm 400$  pounds of sand;
  - ii)  $300 \pm 50$  pounds of soda ash;
  - iii)  $250 \pm 50$  pounds of dolomite;

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- iv)  $70 \pm 50$  pounds of limestone; and
- v) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum;
- B) a quantity of cerous carbonate so as to result in a concentration of cerium oxide in the glass from about 0.8% to about 1.2% by weight;
- C) an amount of iron so as to result in a concentration of total iron in the glass from about 0.75% to about 0.85% by weight; and
- D) about 0.3 to about 0.5 pounds of carbon per 1,000 pounds of glass.

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	18.	A glass	bat	ch co	mpositi	Lon, f	or pro	duci	ng	an	
infra	ared e	nergy a	nd r	adiat	ion abs	orbir	g gree	n-cc	lor	ed gla	iss,
the g	glass	having	a fe	rrous	value	from	about	24%	to	about	27%,
compi	cising	;:									

- A) a soda-lime-silica float glass batch mixture, comprising:
  - i)  $1,000 \pm 400$  pounds of sand;
  - ii)  $300 \pm 50$  pounds of soda ash;
  - iii)  $250 \pm 50$  pounds of dolomite;
  - iv) 70  $\pm$  50 pounds of limestone; and
  - v) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum;
  - B) a quantity of cerous carbonate so as to result in a concentration of ceric oxide in the glass from about 0.5% to about 0.6% by weight;
  - C) a quantity of titanium dioxide so as to result in a concentration of titanium dioxide in the glass from about 0.15% to about 0.25% by weight;
  - D) an amount of iron so as to result in a concentration of total iron in the glass from about 0.75% to about 0.85% by weight; and
  - E) about 0.15 to about 0.3 pounds of carbon per 1,000 pounds of glass.
- 25 19. A glazing, produced from the glass batch composition of claim 1, wherein the Illuminant A visible light transmittance of said glazing is greater than 70%, the total solar energy transmittance of said glazing is less than about 46%, and the ultraviolet radiation transmittance of 30 said glazing is less than about 34%, at a thickness of 4 mm.

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- 20. A glazing, produced from the glass batch composition of claim 11, wherein the Illuminant A visible light transmittance of said glazing is greater than 70%, the total solar energy transmittance of said glazing is less than about 46%, and the ultraviolet radiation transmittance of said glazing is less than about 34%, at a thickness of 4 mm.
- 21. A glazing, produced from the glass batch composition of claim 17, wherein the Illuminant A visible light transmittance of said glazing is greater than 70%, the total solar energy transmittance of said glazing is less than about 46%, and the ultraviolet radiation transmittance of said glazing is less than about 34%, at a thickness of 4 mm.
- 22. A glazing, produced from the glass batch composition of claim 18, wherein the Illuminant A visible light transmittance of said glazing is greater than 70%, the total solar energy transmittance of said glazing is less than about 46%, and the ultraviolet radiation transmittance of said glazing is less than about 34%, at a thickness of 4 mm.
- 23. A vehicle glazing, produced from the glass batch composition of claim 1, wherein said glazing at a thickness of 4 mm has an Illuminant A visible light transmittance greater than 70%, a total solar energy transmittance less than about 46%, an ultraviolet radiation transmittance less than about 34%, an Illuminant C dominant wavelength from about 49% to about 51% nanometers, and a color purity from about 2% to about 3%.

- 24. A vehicle glazing, produced from the glass batch composition of claim 11, wherein said glazing at a thickness of 4 mm has an Illuminant A visible light transmittance greater than 70%, a total solar energy transmittance less than about 46%, an ultraviolet radiation transmittance less than about 34%, an Illuminant C dominant wavelength from about 498 to about 518 nanometers, and a color purity from about 2% to about 3%.
- 25. A vehicle glazing, produced from the glass batch composition of claim 17, wherein said glazing at a thickness of 4 mm has an Illuminant A visible light transmittance greater than 70%, a total solar energy transmittance less than about 46%, an ultraviolet radiation transmittance less than about 34%, an Illuminant C dominant wavelength from about 49% to about 51% nanometers, and a color purity from about 2% to about 3%.
- 26. A vehicle glazing, produced from the glass batch
  20 composition of claim 18, wherein said glazing at a thickness
  of 4 mm has an Illuminant A visible light transmittance
  greater than 70%, a total solar energy transmittance less
  than about 46%, an ultraviolet radiation transmittance less
  than about 34%, an Illuminant C dominant wavelength from
  25 about 498 to about 518 nanometers, and a color purity from
  about 2% to about 3%.
  - 27. A process for melting an infrared energy and ultraviolet radiation absorbing green colored soda-limesilica glass composition, the composition when melted having a ferrous value from about 22% to about 29%, comprising admixing and heating:
    - A) a soda-lime-silica float glass batch mixture;
- B) an ultraviolet radiation absorbing quantity of a cerium containing compound, in an amount which does not substantially affect the color of the glass;

- C) an amount of iron so as to result in at least 0.75 weight percent total iron in the glass; and
- D) a quantity of carbon, which is less than the amount of carbon required to achieve the same ferrous value in a glass produced from a glass batch composition comprising ingredients A, B, and a lesser amount of iron than recited in C;

thereby avoiding the formation of silica scum on the surface of the melt in an amount sufficient to have a deleterious effect on the quality of glass formed by the float process.

- 28. The process for melting a glass composition according to claim 27, wherein said soda-lime-silica float glass batch mixture comprises:
  - A)  $1,000 \pm 200$  pounds of sand;
  - B)  $330 \pm 50$  pounds of soda ash;
  - C)  $250 \pm 50$  pounds of dolomite;
  - D) 70  $\pm$  50 pounds of limestone; and
- 20 E) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum.
- 29. The process for melting a glass composition according to claim 27, wherein said cerium containing compound is selected from the group consisting of cerous carbonate, ceric oxide, cerous oxalate, and ceric hydrate.
- 30. The process for melting a glass composition according to claim 29, wherein said cerium containing 30 compound is cerous carbonate.
  - 31. The process for melting a glass composition according to claim 27, wherein said cerium containing compound is added so as to result in a concentration of cerium oxide in the glass from about 0.8% to about 1.2% by weight.

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32. The process for melting a glass composition according to claim 27, wherein said iron is added so as to result in a concentration of total iron in the glass from 0.75% to about 0.9% by weight.

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33. The process for melting a glass composition according to claim 32, wherein said iron is added so as to result in a concentration of total iron in the glass from 0.75% to about 0.85% by weight.

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- 34. The process for melting a glass composition according to claim 27, wherein the ferrous value in the glass is from about 24% to about 27%.
- 35. The process for melting a glass composition according to claim 27, wherein said carbon is from about 0.15 pounds to about 0.5 pounds per 1,000 pounds of glass.
- 36. The process for melting a glass composition
  20 according to claim 27, further comprising admixing and
  heating a quantity of titanium dioxide, wherein the resultant
  glass contains from about 0.5 to about 0.6 weight percent
  CeO2 and from about 0.15 to about 0.25 weight percent TiO2.
- 25 37. A process for melting an infrared energy and ultraviolet radiation absorbing green colored soda-limesilica glass composition, the composition when melted having a ferrous value from about 24% to about 27%, comprising admixing and heating:
- A) a soda-lime-silica float glass batch mixture, comprising:
  - i)  $1,000 \pm 400$  pounds of sand;
  - ii) 330  $\pm$  50 pounds of soda ash;
  - iii)  $250 \pm 50$  pounds of dolomite;
  - iv) 70  $\pm$  50 pounds of limestone; and

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- v) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum;
- B) an ultraviolet radiation absorbing quantity of a cerium containing compound selected from the group consisting of cerous carbonate, ceric oxide, cerous oxalate, and ceric hydrate, in an amount which does not substantially affect the color of the glass;
- C) an amount of iron so as to result in a concentration of total iron in the glass from 0.75% to about 0.9% by weight; and
- D) a quantity of carbon, which is less than the amount of carbon required to achieve the same ferrous value in a glass produced from a glass batch composition comprising ingredients A, B, and a lesser amount of iron than recited in C;

thereby avoiding the formation of silica scum on the surface of the melt in an amount sufficient to have a deleterious effect on the quality of glass formed by the float process.

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- 38. The process for melting a glass composition according to claim 37, wherein said cerium containing compound is cerous carbonate.
- 39. The process for melting a glass composition according to claim 37, wherein said cerium containing compound is added so as to result in a concentration of cerium oxide in the glass from about 0.8% to about 1.2% by weight.

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40. The process for melting a glass composition according to claim 37, wherein said iron is added so as to result in a concentration of total iron in the glass from 0.75% to about 0.85% by weight.

- 41. The process for melting a glass composition according to claim 37, wherein said carbon is from about 0.15 pounds to about 0.5 pounds per 1,000 pounds of glass.
- 5 42. The process for melting a glass composition according to claim 37, further comprising admixing and heating a quantity of titanium dioxide, wherein the resultant glass contains from about 0.5 to about 0.6 weight percent CeO<sub>2</sub> and from about 0.15 to about 0.25 weight percent TiO<sub>2</sub>.

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- 43. A process for melting an infrared energy and ultraviolet radiation absorbing green colored soda-limesilica glass composition, the composition when melted having a ferrous value from about 24% to about 27%, comprising admixing and heating:
  - A) a soda-lime-silica float glass batch mixture, comprising:
    - i)  $1,000 \pm 400$  pounds of sand:
    - ii) 300 ± 50 pounds of soda ash;
    - iii)  $250 \pm 50$  pounds of dolomite;
    - iv) 70  $\pm$  50 pounds of limestone; and
    - v) 12 ± 8 pounds of a sulfate selected from the group consisting of salt cake and gypsum;
  - B) a quantity of cerous carbonate so as to result in a concentration of cerium oxide in the glass from about 0.8% to about 1.2% by weight;
  - C) an amount of iron so as to result in a concentration of total iron in the glass from about . 0.75% to about 0.85% by weight; and
  - D) about 0.3 to about 0.5 pounds of carbon per 1,000 pounds of glass;

thereby avoiding the formation of silica scum on the surface of the melt in an amount sufficient to have a deleterious effect on the quality of the glass formed by the float process.

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- 44. A process for melting an infrared energy and ultraviolet radiation absorbing green colored soda-limesilica glass composition, the composition when melted having a ferrous value from about 24% to about 27%, comprising admixing and heating:
  - A) a soda-lime-silica float glass batch mixture, comprising:
    - i)  $1,000 \pm 400$  pounds of sand;
    - ii)  $300 \pm 50$  pounds of soda ash;
    - iii) 250 ± 50 pounds of dolomite;
    - iv)  $70 \pm 50$  pounds of limestone; and
    - v) 12  $\pm$  8 pounds of a sulfate selected from the group consisting of salt cake and gypsum;
  - B) a quantity of cerous carbonate so as to result in a concentration of ceric oxide in the glass from about 0.5% to about 0.6% by weight;
    - C) a quantity of titanium dioxide so as to result in a concentration of titanium dioxide in the glass from about 0.15% to about 0.25% by weight;
    - D) an amount of iron so as to result in a concentration of total iron in the glass from about 0.75% to about 0.85% by weight; and
    - E) about 0.15 to about 0.3 pounds of carbon per 1,000 pounds of glass;
- thereby avoiding the formation of silicon scum on the surface of the melt in an amount sufficient to have a deleterious effect on the quality of the glass formed by the float process.

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# INTERNATIONAL SEARCH REPORT

		International Application No PCT	/US91/00624
I. CLASS	IFICATION OF SUBJECT MATTER (if several classific	cation symbols apply, indicate all) 3	
	to International Patent Classification (IPC) or to both Natio 21. (5) CO3C 3/095, 3/087, 4/08 501/64, 70, 905	nal Classification and IPC	
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III. DOCU	IMENTS CONSIDERED TO BE RELEVANT 14		· · · · · · · · · · · · · · · · · · ·
ategory *	Citation of Document, 16 with indication, where appre	opriate, of the relevant passages 17	Relevant to Claim No. 13
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Y	US, A, 4,792,536 (PECORARO), 2 see column 5, lines 10-29, 51-68 and column 9 lin column 10, line 68.	column 6, lines	1-44
Υ.	US, A, 4,701,425 (BAKER ET AL. se column 2 line 31 throug	1-44	
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