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(71) Applicant(s)
Pilkington Plc

(Incorporated in the United Kingdom)

Prescot Road, ST HELENS, Merseyside, WA10 3TT, United Kingdom

(72) Inventor(s)
Kenneth Melvin Fyles
Helen Louise McPhail

(74) Agent and/or Address for Service
Page White & Farrer
54 Doughty Street, LONDON, WC1N 2LS, United Kingdom

(54) **IR and UV absorbent glass compositions**

(57) An infra red and ultra violet soda-lime-silica glass of a neutral tint (as defined in the specification) containing 0.25% to 1.75% by weight total iron expressed as Fe_2O_3 and a ferrous content by weight calculated from the equation:-

$$\%\ \text{by weight FeO} \geq 0.007 + \frac{(\text{Optical density} - 0.036)}{2.3}$$

the glass further including one or more colourants selected from Se, Co_3O_4, Nd_2O_3, NiO, V_2O_5, CeO_2, TiO_2, CuO, MnO and SnO such that the glass, in a 4 mm thickness has a visible light transmission of at least 32%, a direct solar heat transmission at least seven percentage points lower than the visible light transmission and an ultra violet transmission of less than 25%. When Se is present at least one of the specified further oxides is present in an amount at least 1.5 times that of the Se. The dominant wavelength is preferably below 570 nm; if higher, the colour purity is below 4 when the visible light transmission exceeds 60%.

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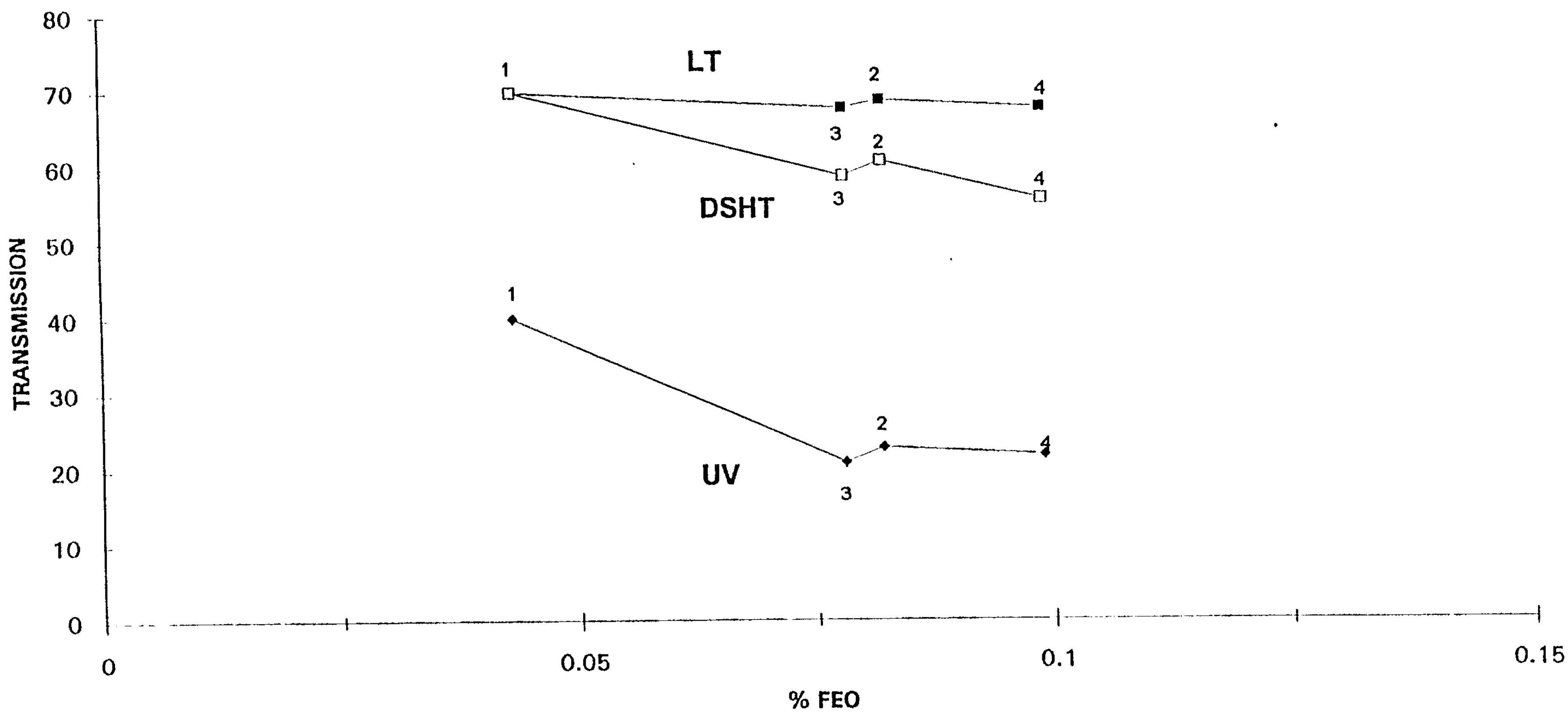
Figure 1: Grey glasses with improved DSHT and UVT performance



Glass Compositions

The present invention relates to infra red (IR) and ultra violet (UV) absorbing soda lime silica glass compositions for use in glazing. More particularly, the present invention relates to windows of a neutral tint made from such glasses primarily, but not exclusively, for vehicles such as motor cars.

Special glasses have been developed for use in vehicles which have low levels of direct solar heat transmission (DSHT) and ultra violet transmission (UVT). These glasses aim to reduce the problems caused by excessive heating within the vehicle on sunny days, and to protect the interior furnishings of the car from the degradation caused by ultra violet radiation. Glasses having good infra red absorption properties are usually produced by reducing iron present in the glass to the ferrous state or by adding copper. Such materials give glasses a blue colour. The materials added to achieve good ultra violet radiation absorption are Fe^{3+}, Ce, Ti or V. The quantities of such materials which are added to provide the desired level of absorption tend to colour the glass yellow. Accordingly, if both good UV and good IR absorption are required in the same glass, the colour of such glass is, almost inevitably, either green or blue. When the colour of the glasses is defined by the CIELAB system, such commercial glasses, in 4 mm thickness and having greater than 60% light transmission, are found to be either very green ($-a^*>8$) or very blue ($-b^*>7$).

neither of which are currently desirable from an aesthetic viewpoint.

Attempts have been made to produce grey or bronze-coloured vehicle glazing having good protection against both IR and UV radiation, but such glasses still tend to have a greenish yellow tinge. Thus, in French Patent Specification No. 2,672,587, the dominant wavelength (λD) of the exemplified glasses varies from 571 to 580 nm, and the colour purity is in the range 4.4 to 15.9%. These figures indicate that such glasses have a greenish yellow tinge. A neutral grey glass, ANTISUN (ANTISUN is a trade mark of the Pilkington Group) Grey, commercially available from Pilkington Glass Limited of St. Helens, England, has a dominant wavelength of 454 and a colour purity of 2.1% in a thickness of 4 mms.

We have identified a requirement for a range of glasses having a neutral tint such that, in the CIELAB system, the glasses have colour co-ordinates lying in the ranges a^* from -6 to +5, b^* from -5 to +5, if the visible light transmission of the glass is above 60% and in the ranges a^* -12 to +5, b^* -5 to +10 if the visible light transmission of the glass is below 60%. The term "neutral tint" is hereinafter used to describe glasses having such colour co-ordinates.

We have further identified a requirement for glasses having a neutral tint which have visible light transmissions greater than 32% (at a thickness of 4 mm), but which also have a direct solar heat transmission which is at least seven percentage points (preferably ten percentage points) less than the visible light transmission. Basically, glasses are known which do have a low direct solar heat transmission but nearly all of these have a low visible light transmission which tend to make such glasses of limited use in vehicles. Glasses satisfying the above-identified requirements should, we anticipated, be of more general use in vehicles due to the higher light transmission but the lower direct solar heat transmission should keep the interior of the car cool despite the higher light transmission.

Furthermore, we believed that it would be desirable if the glasses had an ultra-violet transmission ideally less than 25% because we felt that such a low transmission would minimize the adverse effects of ultra-violet radiation on plastics material and fabrics, particularly in automotive vehicles. At page 5, lines 32 to 35 of French Patent Specification No. 2,672,587 it is pointed out that both CoO and NiO reduce visible light transmission without contributing to either the absorbtion of ultra violet or infra red radiation, and that it is preferable not to add these components. An upper limit of 0.005% is suggested for CoO but the highest CoO content exemplified is 0.001%. This supports the teaching in the specification that these materials should not be used and, if they are, should be present only in limited quantities.

In French Patent 2,672,587, the quantity of Se used in the Examples tends to be of the same order or greater than the amount of tinting agent except in Example 9, where the Fe_2O_3 content is low at 0.178 and the colour purity has a high numerical value 9.6, indicating a substantial departure from a neutral appearance for a 4 mm glass of transmission greater than 60%.

The field of tinted glasses is one in which relatively small changes can produce major changes in tint. As one patentee has said, it is like a hunt for a needle in a haystack. Wide ranges disclosed in prior patents can encompass many possibilities, and it is only the teaching of the specific examples that can be relied on as identifying how particular tints associated with particular ranges of absorption of infra red and ultra violet radiation can be obtained. It is clear that in French Patent 2,672,587, the correct balance of components to achieve a neutral tint free of unacceptable dominance at wavelengths above 570 nm has not been taught. In attempting to get relatively low DSHT, French patent uses high levels of FeO and clearly it has not been recognised, as has been discovered in the present invention, that this can be balanced by addition of tinting agents without an unacceptable loss in visible light transmission.

Our invention is based on the surprising discovery that the incorporation of relatively small amounts of certain colouring agents compensates for the green colour arising from the presence of infra red and ultra violet radiation absorbing components.

According to the present invention, there is provided an IR and UV absorbing soda lime silica glass of a neutral tint (as herein defined) having a ferrous iron content calculated from the equation:-

$$\% \text{ by weight FeO} \geq 0.007 + \frac{(\text{Optical Density} - 0.036)}{2.3}$$

and a total iron content, expressed as Fe_2O_3, in the range of from 0.25 to 1.75% by weight, the glass having been tinted to a neutral colour by one or more of Se, Co_3O_4, Nd_2O_3, NiO, MnO, V_2O_5, CeO_2, TiO_2, CuO and SnO the glass having, in 4 mm thickness, a visible light transmission of at least 32%, a UV transmission not greater than 25%, and a direct solar heat transmission at least 7 percentage points below the visible light transmission, and having a dominant wavelength preferably less than 570 nm; provided that, when the dominant wavelength is above 570 nm and the visible light transmission is greater than 60%, the colour purity is not greater than 4, and preferably less than 2, and that when Se is present, at least one other colourant selected from Co_3O_4, Nd_2O_3, NiO, MnO, CuO, SnO, V_2O_5, CeO_2 and TiO_2 is present in an amount by weight at least 1.5 times the amount of Se present, preferably 2 times as much. Preferably, the direct solar heat transmission is at least 10 percentage points lower than the visible light transmission.

The quantity of Se is preferably kept as low as is compatible with getting a satisfactory neutral colour. We find it possible to operate satisfactorily at less than 5 ppm Se at visible transmissions greater than 60%.

For the purpose of the present specification and claims, references to visible light transmission are to light transmission (LT) measured using CIE Illuminant A; references to UVT are reference to transmissions measured in accordance with the international ISO 9050 standard over the wavelength range 280 to 380 nm; references to direct solar heat transmission (DSHT) are references to solar heat transmission integrated over the wavelength range 350 to 2100 nm according to the relative solar spectral distribution Parry Moon for air mass 2; total solar heat transmission (TSHT) equals DSHT plus the solar heat that is absorbed and reradiated in the forward direction.

Within the general scope of the present invention, there are a number of different types of compositions which are of particular interest.

Thus, in a preferred aspect of the present invention, there is provided a glass having a visible light transmission of up to 60%, a total iron content expressed as Fe_2O_3 of at least 0.7% and a combination of Co_3O_4, NiO and Se as colourants.

The use of nickel as a colourant is somewhat suprising. It is well-known in glass-making that the presence of nickel tends to lead to NiS inclusions in the glass which tend to cause the glass to shatter during tempering. Moreover, glass compositions containing nickel tend to change colour during tempering, particularly bending. For this reason, most prior art in this field tends to the view that the use of nickel should be avoided. For reasons which are not fully understood at the present time, we have found that we are able to use nickel in relatively large quantities, up to 275 parts by million by weight without these problems occurring.

The use of nickel does have some surprising advantages. Firstly, if a series of nickel-containing glasses are being made, there is an easy phase-in from melt to melt. In other words, the amount of nickel being used can be changed without large quantities of wasted glass containing unwanted nickel levels being produced. Furthermore, the use of selenium as a colourant causes problems. It is both volatile and poisonous and the chemical retention thereof in glass is difficult to achieve. In fact, as much as 90% of the selenium introduced into the melt may be discharged unchanged in the exit gases. In addition to its poisonous nature, selenium has a further environmentally-unfriendly characteristic in that it has a foul smell, generally likened to rotting cabbages. It is also well known that the more selenium which is added to a glass melt, the more which proportionately disappears. By using nickel in combination with small quantities of selenium, we have found that we can obtain substantially the same colour tints as were previously obtained using larger quantities of selenium in the absence of nickel. In so doing, we are obviously minimising the adverse environmental effects associated with the use of selenium.

In a different preferred aspect of the present invention, there is provided a glass having a visible light transmission of at least 60%, a total iron content expressed as Fe_2O_3 lying in the range of from about 0.25% to 0.77% by weight and wherein the colourant comprises at least one of V_2O_5, CeO_2, TiO_2, Se, Co_3O_4, NiO, SnO, Nd_2O_3 and MnO.

In such a case, it is desirable if the total iron content is a maximum of 0.3% by weight and the colourant comprises at least one member selected from the group consisting of V_2O_5, CeO_2 and TiO_2 in combination with at least one member selected from the group consisting of Se, Co_3O_4, NiO, Nd_2O_3 and MnO.

If the total iron content is at least 0.3% by weight, it is advantageous if the colourant comprises at least one member selected from the group consisting of Se, Co_3O_4, NiO, Nd_2O_3 and MnO. At least one member of the Group consisting of V_2O_5, CeO_2 and TiO_2 may also be added if desired.

Such glass compositions are also surprising and are extremely useful. This is particularly true if the light transmission is in excess of 70% because, at the current time, this represents the minimal permissible light transmission for the windscreens of vehicles. As previously mentioned, most glasses having the desired IR, visible light and UV transmission characteristics are coloured green. Moreoever, glasses having a high iron content usually have a low light transmission. We have surprisingly found that the green colouration can be easily varied by the use of minimal amounts of other colourants, and selenium in particular, is more optically active, particularly if a high proportion of the iron present is in the ferrous form. The high ferrous content means that small differences of the order of only one or two parts per million of the other colourant(s) can make a substantial difference to the colour of the glass.

Reference should now be made to the accompanying drawing, the single Figure of which is a plot of transmission (UV heat and light) against FeO content for a series of grey glasses showing the improvement in properties that can be achieved, in accordance with the invention, by increasing the FeO content of a known glass (glass 1) while incorporating colourants, as taught in the present invention, to maintain a neutral tint. Glass 1 is commercially available grey glass with a DSHT similar to its light transmission and a UV transmission about 40%. In glasses 2, 3 and 4 the amount of ferrous ion has been increased which, without compensating changes, would normally turn the glass blue and significantly reduce light transmission. The UV transmission has also been reduced which would normally introduce a greenness to the blue glass. The light transmission and neutrality of the glass have in fact been maintained by a balance of cobalt, neodymium, and selenium additions while controlling the ferrous/ferric ratio.

Selenium introduces a pink component to the colour of the glass, thus complementing any blue in the glass to produce a more neutral colour. However, selenium also has colourless forms in oxidised glasses whilst reduced glasses are assumed to contain brown or colourless polyselenides. The oxidation/reduction of the glass must therefore be carefully controlled to retain selenium in the coloured pink form.

Selenium retention is at a maximum at about 20% ferrous/ferric ratio and is significantly reduced below 10% ferrous/ferric or above 40% ferrous/ferric. In glasses using selenium as a neutralising agent the ferrous/ferric ratio should be between 10 and 40% for the best efficiency of retaining selenium in the coloured form.

Although cobalt in itself colours glass blue, it is useful as a colour neutralising agent because its absorptions are in the red end of the visible spectrum and can therefore be useful in counteracting the effect of reduced iron absorption in the infra red at 1050 nm.

Neodymium oxide is also useful in a similar way but is a better neutraliser than cobalt since it is dichroic and produces a blue and pink colouration depending on the kind of light in which it is viewed. However, neodymium oxide is expensive and cobalt in combination with selenium is preferred as a neutralising agent.

For glasses with a DSHT at least 7% points lower than the visible light transmission and a UV transmission of less than 25% in 4 mm path length, the following combination of additives is required.

Total iron expressed as Fe_2O_3 in the range 0.25-1.75%, usually 0.25-1.25%.

The minimum FeO content to provide the necessary DSHT varies with optical density according to the equation

$$\% \text{ FeO} \geqslant 0.007 + \frac{(\text{optical density} - 0.036)}{2.3}$$

where optical density = $\log_{10} {}^{T}/_{100}$

where T is the visible light transmission in percent for 4 mm glass.

This roughly equates to:-

Light Transmission	Minimum FeO Content
80%	0.033%
70%	0.058%
60%	0.087%
50%	0.122%
40%	0.153%
30%	0.218%

Ultraviolet absorption will be provided by iron oxide in the Fe^{3+} state, optionally supplemented by V_2O_5 and/or CeO_2 and/or TiO_2. For most tints, a UV transmission of less than 25% is met simply by ferric iron. However, where the ferric iron is less than 0.3% expressed as Fe_2O_3, the UV transmission may be reduced below 25% by additions of:-

0.1 - 1.0 CeO_2 (if vanadium is absent)

0.05 - 0.2 V_2O_5 (if cerium is absent)

Many of the glasses contain at least 0.3% ferric iron expressed as Fe_2O_3 and in addition have quantities of CeO_2 and V_2O_5 to provide enhanced UV protection.

Preferably the DSHT shall be at least 10% points lower than the visible light transmission; the minimum FeO content of the glass to meet this preferred condition is given by

$$\%FeO \geqslant 0.012 + \frac{(\text{optical density} - 0.036)}{1.84}$$

This roughly equates to:

Light Transmission	Minimum FeO Content
80%	0.045%
70%	0.076%
60%	0.113%
50%	0.156%
40%	0.208%
30%	0.276%

For the most neutral tints the ferrous/ferric ratio shall not be less than 10% and preferably not less than 18%.

A required tint may be achieved by adding one or more of Se, Co_3O_4, Nd_2O_3, NiO, MnO, CuO and SnO. The quantities of colourant and the colourant chosen to decolourise depends on the depth of tint required and the following guide lines are given.

Se	up to 50 parts per million chemical Se retained
Co_3O_4	up to 200 parts per million
Nd_2O_3	up to 2.5% by weight

Manganese oxide may also be added to the glass to provide pinkness due to the presence of the Mn^{3+} ion but it is preferably limited to a maximum of 1% by weight because of the danger of colour changes caused by solarisation. Similarly, cerium and vanadium oxide ultra violet absorbers in the same glass must be carefully used because of the possibility of colour changes by solarisation.

Other components which may be present in glasses in accordance with the invention include copper oxide, CuO typically in an amount up to 0.1% by weight, which in certain conditions may reduce solar heat transmission.

The glasses in accordance with the invention are useful for both architectural and automotive purposes, and the invention also provides windows composed of glass in accordance with the invention. The automotive windows may be not only windscreens, but also the remaining windows of a car. These can eg include rear side windows with visible light transmissions as low as 30% and a rear screen as low as 30%.

The Examples, except Example 1 which is for comparison purposes only, illustrate but do not limit the invention. In the Examples, all parts and percentages are by weight and:

(a) Fe_2O_3, FeO, Nd_2O_3, CeO_2, TiO_2, V_2O_5, SnO and MnO are expressed in percent; Se, Co_3O_4 and NiO are expressed in parts per million;

(b) total iron is expressed as if all iron present were present as ferric oxide;

(c) percentage of total iron as Fe^{2+} is calculated from the spectral curve of the glass using the equation:-

$$\%Fe^{2+} = \frac{115.2\ (OD_{1000} - 0.036)}{t \times Fe_2O_3}$$

where OD_{1000} = optical density of the glass at 1000 nm wavelength

t = glass thickness in millimetres

Fe_2O_3 = percentage total iron, expressed as Fe_2O_3, in the glass; and

(d) the FeO content is calculated from the equation

$$\%FeO = \frac{\%Fe^{2+}}{100} \times Fe_2O_3 \times \frac{143.7}{159.7}$$

Fe_2O_3 = percentage total iron, expressed as Fe_2O_3, in the glass

(143.7 being the molecular weight of 2 x FeO and 159.7 being the molecular weight of Fe_2O_3).

Examples

CHEMICAL ADDITIVES

	Total iron as Fe_2O_3 %	FeO %	% of total iron as $Fe2^+$	Se	Co_3O_4	Nd_2O_3	CeO_2	TiO_2	V_2O_5	Other
1	0.25	0.043	18%	11	41	-	-	-	-	-
2	0.35	0.082	26%	3	32	0.15	0.4	-	-	-
3	0.38	0.078	23%	5	32	-	0.34	-	-	-
4	0.38	0.099	29%	2	32	-	0.4	-	-	-
5	0.25	0.038	17%	9	-	-	-	-	0.1	-
6	0.25	0.065	29%	3	-	-	-	-	0.1	-
7	0.34	0.098	32%	<2	32	-	0.4	-	-	-
8	0.45	0.030	7.5%	24	18	-	0.4	-	-	-
9	0.45	0.093	23%	5	38	-	0.4	-	-	-
10	0.45	0.142	35%	<2	38	-	0.4	-	-	-
11	0.45	0.154	38%	<2	38	-	0.4	-	-	-
12	0.45	0.117	29%	<2	-	0.2	0.4	-	-	-
13	0.45	0.126	31%	<2	-	0.5	0.4	-	-	-
14	0.45	0.122	30%	<2	-	0.3	0.4	-	-	-
15	0.45	0.142	35%	<2	38	-	0.5	0.25	-	-
16	0.45	0.134	33%	<2	-	-	0.4	0.2	-	-
17	0.45	0.142	35%	<2	-	0.3	0.4	-	-	NiO 100ppm
18	0.45	0.146	36%	5	-	0.3	0.4	-	-	-
19	0.45	0.130	32%	16	25	-	0.4	-	-	-
20	0.4	0.104	29%	8	30	-	0.4	-	-	-
21	0.45	0.150	37%	10	38	-	0.4	-	-	SnO 1.0
22	0.4	0.097	27%	4	18	-	-	-	0.1	-
23	0.6	0.124	23%	<2	20	-	0.2	-	-	-
24	0.7	0.088	14%	<2	-	0.7	1.0	-	-	-
25	0.7	0.157	25%	7	38	-	-	-	-	-
26	0.77	0.090	13%	-	-	0.5	1.0	0.5	-	-
27	0.5	0.122	27%	12	76	-	0.1	-	-	-

	Total iron as Fe_2O_3 %	FeO %	% of total iron as Fe^{2+}	Se	Co_3O_4	Nd_2O_3	CeO_2	TiO_2	V_2O_5	Other
28	0.45	0.146	36%	7	80	-	-	-	-	-
29	0.675	0.213	35%	9	57	-	-	-	-	-
30	1.23	0.443	40%	11	104	-	-	-	-	-
31	0.675	0.182	30%	14	57	-	-	-	-	-
32	0.7	0.227	36%	20	80	-	-	-	-	-
33	0.7	0.227	36%	20	120	-	-	-	-	-
34	0.7	0.258	41%	16	120	-	-	-	-	-
35	0.675	0.249	41%	3	57	-	0.2	1.0	-	-
36	0.9	0.300	37%	10	20	-	-	-	-	-
37	0.7	0.290	46%	11	Zero	2.0	-	-	-	-
38	0.8	0.209	29%	24	81	-	-	-	-	-
39	1.0	0.225	25%	14	150	-	-	-	-	-
40	0.6	0.086	16%	-	20	-	0.4	-	-	MnO_2 1.0
41	0.6	0.162	30%	<2	20	0.1	-	-	-	-
42	0.7	0.258	41%	15	120	-	-	-	-	NiO 275ppm
43	1.0	0.315	35%	9	20	-	-	-	-	-
44	1.23	0.277	25%	12	104	-	-	-	-	-
45	1.40	0.252	20%	10	104	-	-	-	-	-
46	1.30	0.257	22%	5	130	-	-	-	-	NiO 131 ppm
47	0.9	0.186	23%	6	65	-	-	-	-	NiO 65 ppm
48	1.1	0.346	35%	13	105	-	-	-	-	NiO 131 ppm
49	0.8	0.173	24%	12	30	0.5	-	-	-	-
50	0.6	0.167	31%	11	30	0.5	-	-	-	-
51	0.6	0.157	29%	17	80	1.0	-	-	-	-
52	0.45	0.146	36%	7	80	-	-	-	0.05	-
53	0.6	0.119	22%	20	-	1.0	-	-	-	-

TRANSMISSION COLOUR

	LT	DSHT	UVT	a*	b*	Dominant wavelength λD	Colour Purity
1	70	70	40	-0.3	1.1	454	2.1%
2	69	61	23	-1.9	-1.4	485	2.7%
3	68	59	21	-0.8	+2.0	570	1.2%

	LT	DSHT	UVT	a*	b*	Dominant wavelength λD	Colour Purity
4	68	56	22	-2.4	-0.6	489	2.2%
5	82	75	17	-2.2	+4.9	569	3.9%
6	80	69	23	-4.5	+4.5	558	3.1%
7	73	59	25	-3.5	-3.2	486	4.9%
8	80	72	23	-1.4	+1.6	547	0.5%
9	64	55	20	-1.4	+1.5	547	0.6%
10	64	48	22	-3.7	-1.9	488	4.0%
11	64	46	23	-4.9	-3.8	487	6.1%
12	72	54	20	-3.0	+2.2	530	0.9%
13	71	55	22	-4.0	-1.6	489	3.9%
14	73	56	22	-3.4	+0.6	495	1.7%
15	64	47	17	-4.3	-0.6	492	3.1%
16	74	52	20	-4.6	+3.0	534	1.6%
17	67	49	22	-4.5	+2.3	515	1.3%
18	65	47	18	-2.3	+3.7	564	2.8%
19	57	46	15	+1.0	+9.0	553	3.0%
20	64	54	20	-0.3	+3.8	576	3.4%
21	60	47	19	-1.9	+2.1	553	1.1%
22	69	57	18	-4.7	+4.3	553	3.0%
23	71	54	22	-3.8	+1.0	499	1.5%
24	67	58	11	-2.0	+3.7	566	2.7%
25	61	45	21	-4.4	+0.5	493	3.3%
26	73	60	8	-5.7	+3.9	536	2.2%
27	48	41	18	-0.8	+1.1	552	0.4%
28	51	42	22	-3.8	-2.1	488	4.5%
29	50	35	20	-4.0	-0.2	493	2.8%
30	30	16	9	-8.8	-4.1	489	10.3%
31	49	36	17	-2.5	+2.5	553	1.7%
32	39	29	13	-0.7	+4.9	574	5.6%
33	33	25	12	-1.0	+0.9	511	0.3%
34	37	27	16	-3.3	-4.3	484	6.9%
35	54	36	15	-7.4	-1.3	492	5.5%
36	51	29	16	-6.6	+3.3	521	2.1%
37	40	28	15	-3.5	-3.4	486	6.0%
38	36	27	9	+0.6	+8.4	578	10.9%
39	33	26		-3.9	-5.0	485	8.3%
40	75	60	13	-6.0	+4.4	543	2.7%
41	69	49	23	-5.8	-2.5	489	5.4%
42	34	25	17	-4.0	+1.4	504	1.7%
43	52	28	15	-9.5	+0.3	496	5.3%
44	36	24	7	-5.7	+0.4	496	3.6%
45	39	27	5	-7.4	+0.1	496	4.7%
46	35	25	7	-7.8	-1.0	493	6.3%
47	53	38	16	-6.7	-1.2	492	5.1%
48	32	20	9	-7.2	+0.8	498	4.3%
49	38	26	8	-3.5	+5.0	563	4.9%
50	41	28	13	-3.4	+1.2	501	1.6%

	LT	DSHT	UVT	a*	b*	Dominant wavelength λD	Colour Purity
51	35	27	9	-0.5	+4.6	575	5.4%
52	51	42	22	-3.8	-2.1	487	4.5%
53	40	33	8	+2.4	+10.0	581	13%

Several of the examples given are suitable as high performance architectural glasses for buildings because of their superb infra-red and UV absorbance combined with neutrality of colour. The properties of architectural glasses are often quoted in 6 mm path length and the Total Solar Heat Transmission (TSHT) is quoted in addition to the DSHT. Some examples particularly suitable for architectural use are as follows:-

Transmission in 6 mm path length

Example	Light Transmission	DSHT	TSHT	UVT
3	58%	48%	60%	15%
7	65%	48%	60%	20%
11	55%	36%	51%	17%
13	63%	44%	57%	16%
14	65%	44%	57%	16%
23	63%	44%	57%	16%

Claims

1. An IR and UV absorbing soda lime silica glass of a neutral tint (as herein defined) having a ferrous iron content calculated from the equation:-

$$\% \text{ by weight FeO} \geqslant 0.007 + \frac{(\text{Optical density} - 0.036)}{2.3}$$

and a total iron content expressed as Fe_2O_3 in the range 0.25 - 1.75% by weight,
the glass having been tinted to a neutral colour by one or more of Se, Co_3O_4, Nd_2O_3, NiO, MnO, V_2O_5, CeO2, TiO_2, CuO and SnO,
the glass having, in a 4 mm thickness, a visible light transmission of at least 32%, a UV transmission not greater than 25%, and a direct solar heat transmission at least 7 percentage points below the visible light transmission, and having a dominant wavelength preferably less than 570 nm, provided that, when the dominant wavelength is above 570 nm and the visible light transmission is greater than 60%, the colour purity is not greater than 4,
and when Se is present, at least one other colourant selected from Co_3O_4, Nd_2O_3, NiO, MnO, CuO, SnO, V_2O_5, CeO_2 or TiO_2 is present in an amount by weight at least 1.5 times the amount of Se present.

2. A glass as claimed in claim 1 having a visible light

transmission of up to 60%, a total iron content expressed as Fe_2O_3 of at least 0.7% and a combination of Co_3O_4, NiO and Se as colourants.

3. A glass as claimed in claim 1 having a visible light transmission of at least 60%, a total iron content expressed as Fe_2O_3 lying in the range of from about 0.25% to 0.77% by weight and wherein the colourant comprises at least one of V_2O_5, CeO_2, TiO_2, Se, Co_3O_4, NiO, SnO, Nd_2O_3 and MnO.

4. A glass as claimed in claim 3 wherein the total iron content is a maximum of 0.3% by weight and the colourant comprises at least one member selected from the group consisting of V_2O_5, CeO_2 and TiO_2 in combination with at least one member selected from the group consisting of Se, Co_3O_4, NiO, Nd_2O_3 and MnO.

5. A glass as claimed in claim 3 wherein the total iron content is at least 0.3% by weight and the colourant comprises at least one member selected from the group consisting of Se, Co_3O_4, NiO, Nd_2O_3 and MnO.

6. A glass as claimed in claim 1 wherein the colourants comprise a mixture of at least three members of the group consisting of Se, Co_3O_4, Nd_2O_3, CeO_2, TiO_2, V_2O_5, NiO, MnO, SnO and CuO.

7. A glass as claimed in claim 6 wherein at least one of the three colourants is selected from the sub-group consisting of V_2O_5, CeO_2 and TiO_2 and at least one of the other colourants is selected from the sub-group consisting of Se, Co_3O_4, Nd_2O_3, NiO, MnO, SnO and CuO.

8. A glass as claimed in any one of claims 3 to 7 wherein Nd_2O_3 is present in an amount of up to 2.5% by weight.

9. A glass as claimed in any one of claims 3 to 7 wherein MnO is present in an amount of up to 1% by weight.

10. A glass as claimed in any one of claims 3 to 7 wherein CeO_2 is present in an amount of from about 0.1% to 1% by weight.

11. A glass as claimed in any one of claims 3 to 7 wherein V_2O_5 is present in an amount of from 0.05% to 0.2% by weight.

12. A glass as claimed in any one of claims 2 to 7 wherein Se is present in an amount of up to 50 parts per million by weight.

13. A glass as claimed in any one of claims 2 to 7 wherein Co_3O_4 is present in an amount of up to 200 parts per million by weight.

14. A glass as claimed in any one of claims 2 to 7 wherein NiO is present in an amount of up to 275 parts per million by weight.

15. A glass as claimed in claim 2 containing up to 275 parts per million by weight NiO, up to 15 parts per million by weight Se and up to 130 parts per million by weight Co_3O_4.

16. A glass as claimed in claim 3 wherein Se is present in an amount of up to 5 parts per million by weight.

17. A glass as claimed in claim 1 having a visible light transmission of up to 60%, a total iron content expressed as Fe_2O_3 of at least 0.8% by weight and a combination of Co_3O_4 and Se as colourants.

18. A glass as claimed in claim 17 wherein the Co_3O_4 is present in an amount of up to 150 parts per million by weight and Se is present in an amount of up to 15 parts per million by weight.

19. A glass as claimed in any preceding claim having a ferrous content of at least 18% of the total iron.

20. An IR and UV absorbing glass as claimed in any preceding claim having, in 4 mm thickness, a direct solar heat

transmission at least 10 percentage points below its visible light transmission.

21. An IR and UV absorbing glass as claimed in claim 1 having, in 4 mm thickness, a dominant wavelength above 570 nm, a visible light transmission greater than 60% and a colour purity less than 2.

22. An IR and UV absorbing glass as claimed in any preceding claim containing Se and at least one other colourant selected from Co_3O_4, Nd_2O_3, NiO and MnO in an amount by weight which is at least twice the amount of Se present.

23. An IR and UV absorbing glass having a neutral tint substantially as hereinbefore described in any one of the Examples.

24. An IR and UV absorbing glass according to any of the preceding claims in sheet form.

25. A window composed of glass according to any of the preceding claims.

26. An automotive window composed of glass according to any of the preceding claims.

27. A glass substantially as hereinbefore described with reference to any of the foregoing Examples Nos 2 to 53.

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9401373.7
Relevant Technical Fields (i) UK Cl (Ed.M) C1M (MAL, MAG) (ii) Int Cl (Ed.5) C03C 4/08	Search Examiner R E HARDY
	Date of completion of Search 25 MARCH 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) WPI	Documents considered relevant following a search in respect of Claims :- ALL

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
P,X	EP 0565882 A1	(CENTRAL GLASS) (published 14 October 1994) see the examples	1 at least
X	EP 0507985 A1	(FLACHGLAS) see the examples	1 at least
X	EP 0482535 A1	(PPG) see the examples	1 at least
P,X	US 5264400 A1	(NAKAGUCHI) (published 23 November 1993) see the examples and column 3 lines 33-38	1 at least
X	US 4713359 A	(LUBELSKI) see the examples	1 at least
X	US 4701425 A	(BAKER) see the examples	1 at least

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