GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 10, NO. 2, MARCH 2004: 327 - 334
COPYRIGHT(C) BACHUDO SCIENCE CO. LTD. PRINTED IN NIGERIA. ISSN 1118-0579

PERCENTAGE ABSORBANCE AND TRANSMITTANCE OF VARIOUS TYPES OF GLASSES

L. E. AKPABIO, E. E. ENO and B. E. BASSEY

(Received 23 July 2003; Revision accepted 16 October 2003)

ABSTRACT

Studies have been made on the Percentage Absorbance and Transmittance of various types of glasses in the Ultra-Violet (UV) and Visible (Vis.) Spectrum (between the wavelength range of 200nm and 800nm). The 6mm thick plain louvre glass absorbed more than other plain louvre glasses with smaller thickness. The same results were obtained for coloured glasses. The coloured glasses absorb less in their respective colour range and hence transmit more in such range. Hence, it is recommended that thick coloured and 6mm plain louvre glasses should be used to reduce the load on the air-conditioners inside buildings, while plain louvre glass of smaller thickness be used as glazing material in flat plate solar collectors and possibly in long term storage elements.

KEYWORDS: Absorbance, Transmittance, Glass.

INTRODUCTION

Translucent or transparent insulation materials are already in the market. The optical properties of such materials namely, the ability to absorb and transmit is of great importance when considering its application in improving the energy balance of buildings, factories, automobiles and other services. Glass is the oldest and best known of such materials. There is need to study some of the optical properties of glass (Eno and Akpabio, 2000). Most glass have a chemical composition of many metal oxides and silicon as well as additives, such as different colouring compounds used in glass manufacturing (Weyl, 1959).

Physical and chemical properties of glass have been studied widely (Stanworth, 1950; Holloway, 1973 and Jones, 1979) and very few developing Countries such as Iraq (Al-Azzawi and Yasin, 1985) have shown some interest in these properties of glass. The rest of the developing Countries (such as Nigeria) give little attention to this aspect, even though glass has been used widely and many glass industries have been built.

The objective of this research is to determine the ability of different types of glasses of various thicknesses to absorb and transmit different wavelength of radiation. It is expected also that the composition of the different types of glass should affect their respective optical behaviour as well as a function of the radiation wavelength.

THEORY

A beam of light of intensity, I_o, incident on any interface is usually absorbed, transmitted and reflected. If I_a, I_t and I_r are the intensities of absorbed, transmitted and reflected radiation respectively, then (Duffie and Beckman, 1974; Meinel and Meinel, 1977 and Twidell and Weir, 1990)

$$I_o = I_a + I_t + I_r \quad (1)$$

or

$$A + R + T = 1 \quad (2)$$

Where $A = I_a / I_o$ = Absorptance,

$R = I_r / I_o$ = Reflectance and

$T = I_r / I_o$ = Transmittance at a particular wavelength.

Where the reflectance cannot be measureu, the defining equation is

$$R = 1 - (A + T). \quad (3)$$

L. E. AKPABIO, Dept. of Physics, University of Uyo, Uyo, Akwa Ibom State, Nigeria.
E. E. ENO, Dept. of Physics, University of Uyo, Uyo, Akwa Ibom State, Nigeria.
B. E. BASSEY, Dept. of Physics, University of Uyo, Uyo, Akwa Ibom State, Nigeria

The most important optical property of glass is the ability to transmit light. The ratio of the intensity of the transmitted light to the intensity of the incident light, is defined as transmission with losses in radiation due to reflection and absorption. The relationship between these properties are given as (Shand, 1958):

$$T = I / I_o = (1 - R)^2 e^{-\alpha x}$$

i.e $$T = Ke^{-\alpha x} \quad (4)$$

where T = overall transmission,
I_o = intensity of the incident light,
I = intensity of the transmitted light,
K = the losses in the intensity due to reflectivity = $(1 - R)^2$,
R = the ability of reflectivity,
α = extinction coefficient.

MATERIALS AND EXPERIMENTAL METHOD

Sixteen glass specimens of different types and thickness, including coloured, wired and laminated types, were collected from various sources and cut into the dimensions given in Table 1.

TABLE 1: GLASS SPECIMENS WITH THEIR SOURCES

S/NO	GLASS SPECIMEN	PREPARED DIMENSION (mm) LENGTH x WIDTH x THICKNESS	SOURCE
1.	Plain Louvre	75 x 25 x 2	Int. Glass Industry, Aba.
2.	Plain Louvre	71 x 25 x 3	Int. Glass Industry, Aba.
3.	Plain Louvre	75 x 24 x 4	No. 82 Aka Road, Uyo.
4.	Plain Louvre	75 x 24 x 5	Int. Glass Industry, Aba.
5.	Plain Louvre	75 x 23 x 6	No. 82 Aka Road, Uyo.
6.	Obscured Louvre	74 x 25 x 5	Int. Glass Industry, Aba.
7.	Plain Flora	74 x 24 x 3	Int. Glass Industry, Aba.
8.	Pink Flora	76 x 24 x 3	No. 82 Aka Road, Uyo.
9.	Yellow Flora	76 x 25 x 3	Int. Glass Industry, Aba.
10.	Blue Flora	75 x 25 x 3	No. 82 Aka Road, Uyo.
11.	Plain Wired	73 x 25 x 3	Int. Glass Industry, Aba.
12.	Tinted or Bronze Wired	73 x 25 x 5	Int. Glass Industry, Aba.
13.	Obscured Tinted	73 x 25 x 4	No. 82 Aka Road, Uyo.
14	Tinted or Bronze	71 x 24 x 5	Int. Glass Industry, Aba.
15.	Laminated (Car Windscreen)	65 x 23 x 6	Emmco Mechanical Workshop, Uyo.
16.	Cool Reflective	75 x 24 x 5	Int. Glass Industry, Aba

For the measurement of absorbance and transmittance for the glass specimens, air was used as the "Base-line" [i.e. within the selected wavelength range (200 – 800nm), the absorbance and transmittance by air were cancelled].

The glass specimens were placed vertically in the specimen holders in the cell compartment such that light was incident normally on it for absorbance and transmittance measurements. The absorbance and transmittance spectra of glass specimens were determined by using Unicam 8700 Series UV / Vis. Spectrophotometer in the range of 200 to 800nm.

RESULTS AND DISCUSSION

Percentage Absorbance

It is quite obvious that the percentage absorbance varies with glass thickness as in Fig. 1 for plain louvre glasses. And there are no new absorption peaks due to differences in the thickness of the plain louvre glasses. In Fig. 2 is the percentage absorbance for different flora glasses of the same thickness (3mm). We find that 3mm thick plain flora glass exhibits the same absorbance structure as the 3mm thick plain louvre glass, with the former absorbing more throughout the observed wavelength regions. It is interesting to see that Yellow Flora absorbs least in the Yellow wavelength (about 575nm) and the Blue Flora least in the Blue wavelength (about 450nm). Hence, the colouring of the Flora glass affects the absorbance property of this type of glass.

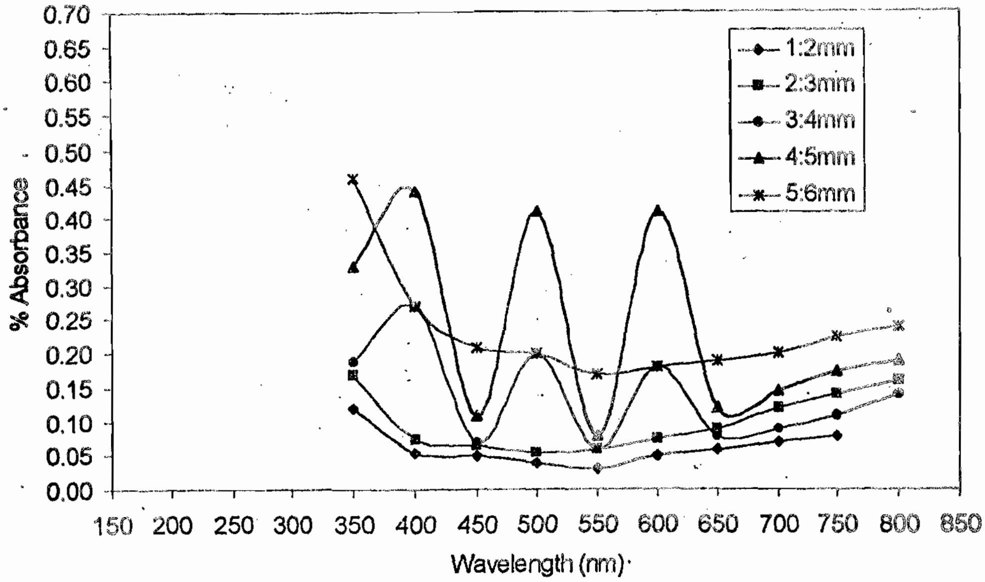

Fig. 1: Percentage absorbance of radiation by plain louvre glass of 2,3,4,5 and 6mm thickness.

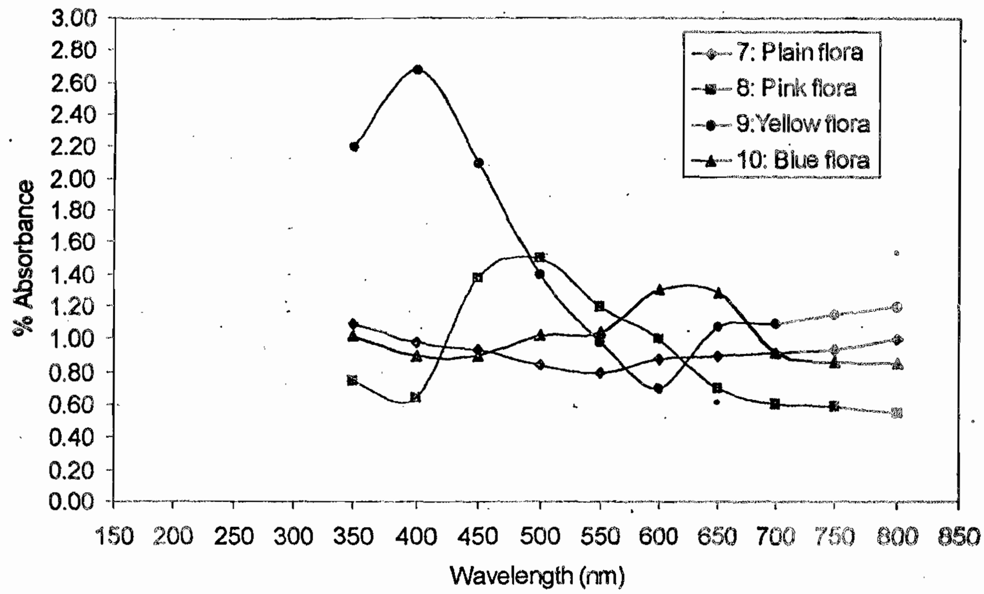

Fig. 2: Percentage absorbance of radiation by Flora glass of different colours.

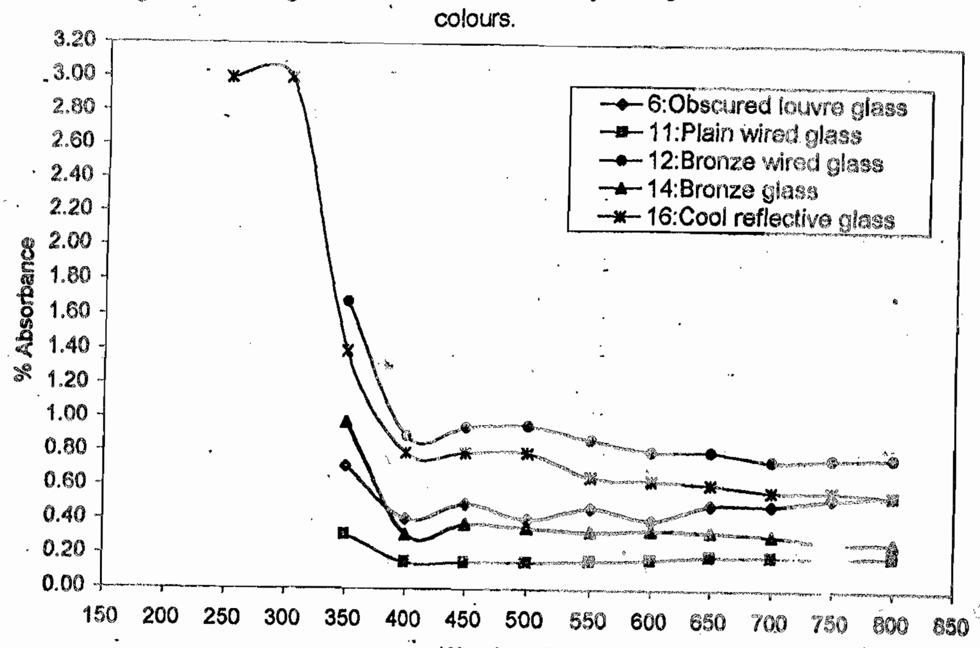

Fig. 3: Percentage absorbance of radiation for five different glass specimens (6,11,12,14 and 16) with the same thickness of 5mm.

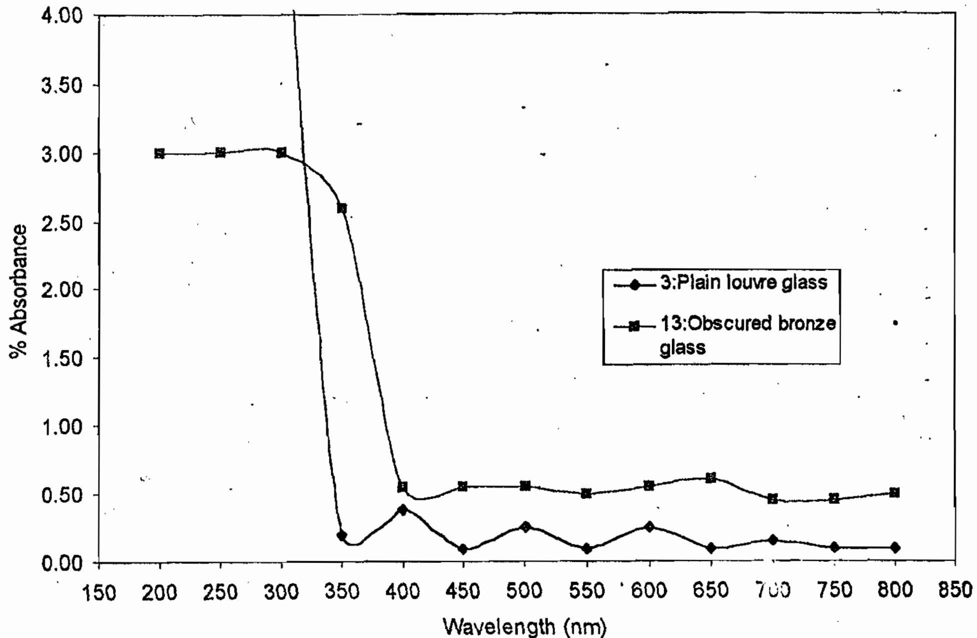

Fig. 4: Percentage absorbance of radiation for two different glass specimens (3 and 13)with the same thickness of 4mm.

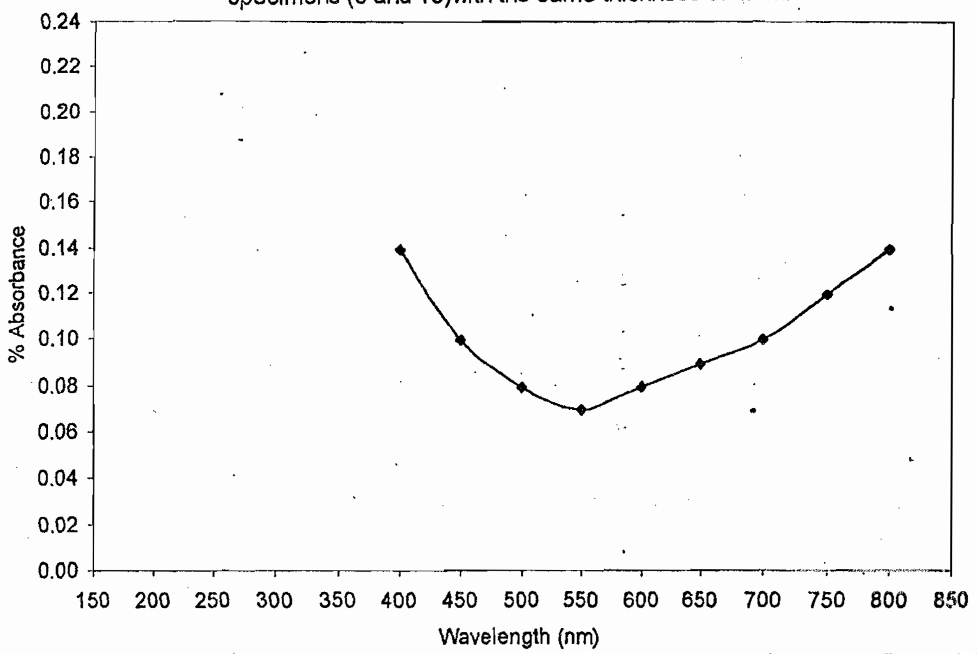

Fig. 5: Percentage absorbance of radiation by Laminated glass (car windscreen, 5mm thick).

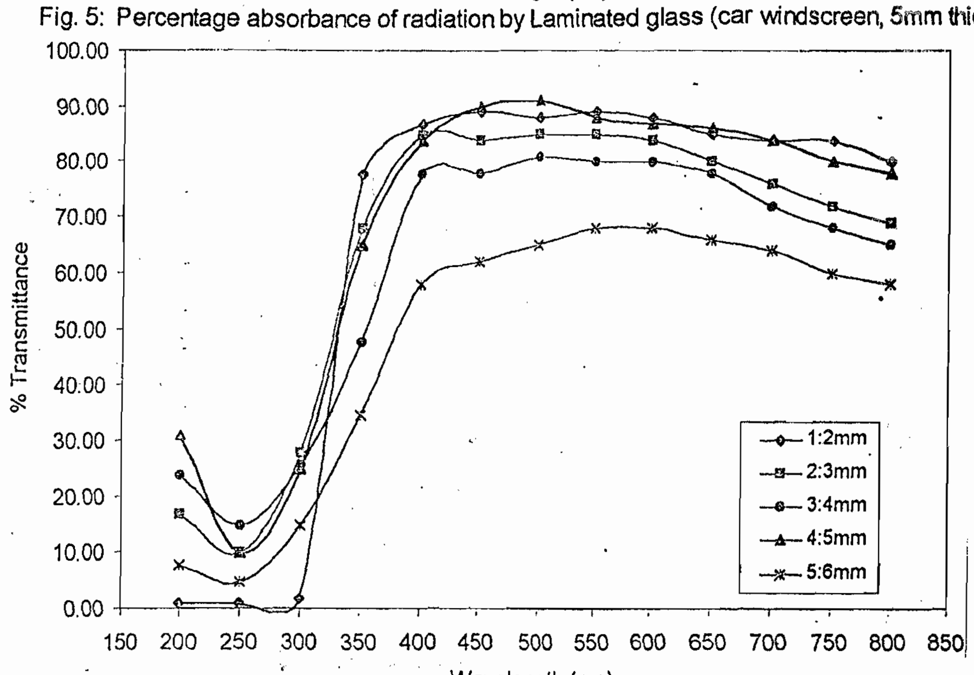

Fig. 6: Percentage Transmittance of radiation by plain louvre glass of 2,3,4,5 and 6mm thickness.

The spectral absorbances of the same thickness (5mm) of various types of glass are presented in Fig. 3. It is fair to suggest that those glass types all show the same absorption edge at about 300nm. These different types of glass however exhibit different absorption peaks throughout the observed spectral region. The percentage absorbance in increasing order is indicated by Plain wired (11), Bronze glass (14), Obscured louvre glass (6), Cool reflective glass (16) and Bronze wire glass (12) in that order.
The absorbance peaks in Fig. 4 is similar to Fig. 3 except that here the thickness is 4mm for the glass samples instead of 5mm. From Fig. 5, the absorbance for car windscreen decreased from 0.15% at 400nm to 0.07% at 550nm before it increased to 0.14% at 800nm. This shows that Car windscreen absorbed more of Visible light than Ultraviolet radiation.

Percentage Transmitance

The spectral transmittance of plain louvre glass of different thickness is as shown in Fig. 6 It is quite clear from the figure that, the transmission depends on the thickness of the glass types (Al-Azzawi and Yasin, 1985). All of them transmit evenly in the Visible region. In Fig. 7, it is clearly seen that colours affect the transmittance properties of the 3mm different glass samples. Fig. 8 represents a set of transmittance curves for different types of glass of the same thickness (5mm). A comparison of the percentage transmittance in each case shows that sample 11 exhibits the greatest transmitting ability followed by samples 14, 16 and 12 in that order. This is very much in line with out observations of the corresponding absorbance properties Fig. 3. The sample with the greatest transmittance shows the least absorbance.

The results shown in Fig. 9 where two glass samples of 4mm thickness were used are similar to that of Fig. 8. The transmittance for Car windscreen in Fig. 10 increases from 65% at 400nm to 75% at 450nm but remain between 69% and 78% from 500nm to 800nm. A comparison of Fig. 5 and Fig. 10 shows that Car windscreen has greatest transmittance in the Visible light spectrum than absorbance.

DISCUSSION

We have analysed the Percentage Absorbance and Transmittance of various glass types available in our markets. Our results indicate that all the louvre glasses transmit more throughout the Visible spectral region as expected; which may be the reason for their common use in buildings.

Measurements on coloured Flora glasses give the absorption of some parts of the electromagnetic spectrum in the Visible region. This effect of coloured glasses can be applied to simplifying building designs (e.g. construction of an overhang within certain dimensions so as to prevent most of the Dry Season's sun and allow most of the Rainy Season's sun) and other services.

All the coloured Flora glasses absorb less than others in their respective colour range. This is due to the fact that, there are colored in the first place and as such are almost saturated with that colour. Hence, Yellow Flora glass for example is Yellow because it will only transmit colour in that frequency, while it absorbs the other parts of the Visible spectrum. The physical basis to glass colouring is due to selective absorption and scattering which is as a result of the impurities in the glass (Weyl, 1959).

An important point to note also is the role of the chemical composition of the glass samples. The variations seen in Fig.3 where all the different types of glass samples have the same thickness of 5mm are clearly due to the chemical composition. The chemical composition of Bronze wired glass (5mm thick) favours its absorption ability a lot compared to other glass samples of the same thickness (Fig. 3).

The variation of the optical properties with sample thickness is clear. The thicker the glass sample, the greater the absorption ability, which implies less transmission and vice-versa.

Plain glass may also be used as storage elements. When sensible heat is stored in a tank filled with water, then inevitably heat losses through walls and feed-through lead to a loss of the energy stored within a relatively short time (Goetzberger, 1987). If the tank is covered with a layer of plain glass sheets, there will be a continuos gain from Solar radiation.

CONCLUSION

A survey has been presented on the percentage absorbance and transmittance of various types of glasses in the UV and Visible spectrum. From all the results obtained, it is established that increase in thickness of the different glass types improves their percentage absorbance while decreasing transmittance. Hence, the plain louvre glass with 6mm thickness reduces transmittivity and has good visible quality that makes it suitable in buildings. Plain louvre glasses of smaller thickness are also recommended for use as glazing fmaterials in flat plate solar collectors.

Deep coloured glass may have disadvantage because of their poor visibility quality, while light coloured glass such as gray gives the most suitable result. Hence, the coloured Flora glasses are

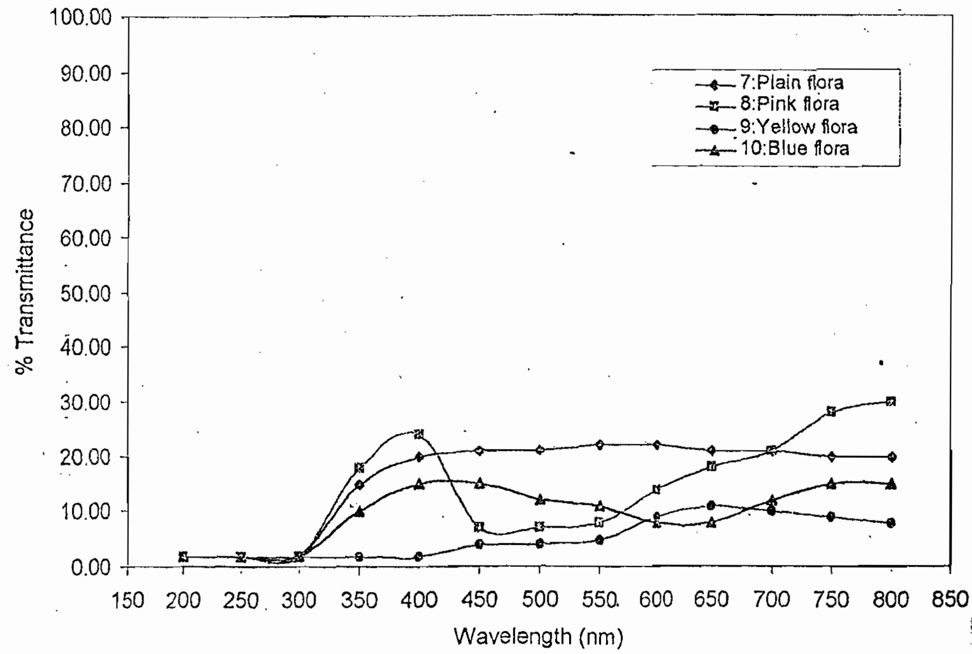

Fig. 7: Percentage Transmittance of radiation by Flora glass (3mm thick) of different colours.

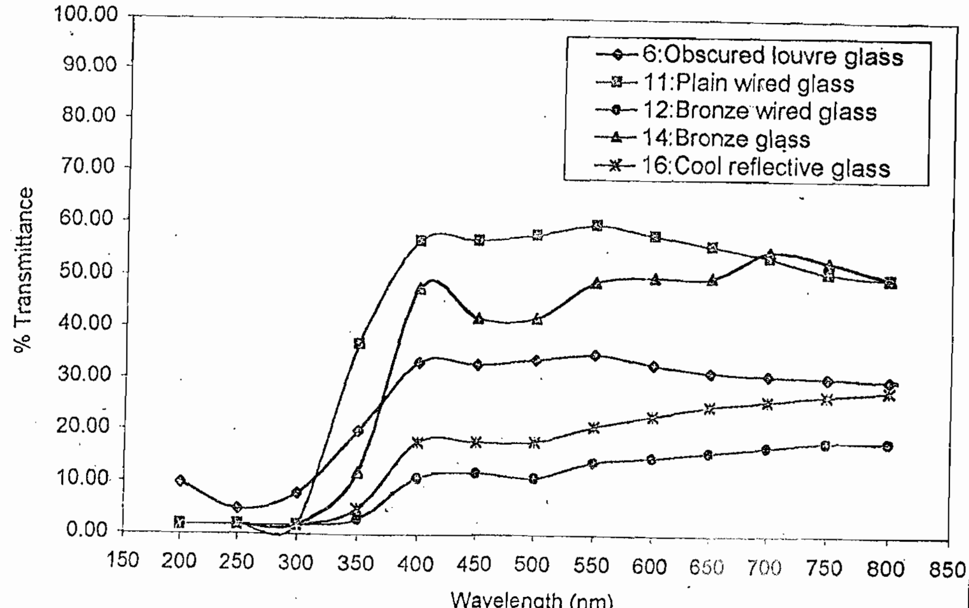

Fig. 8: Percentage Transmittance of radiation of five different glass specimens (6,11,12,14,and 16) with the same thickness of 5mm.

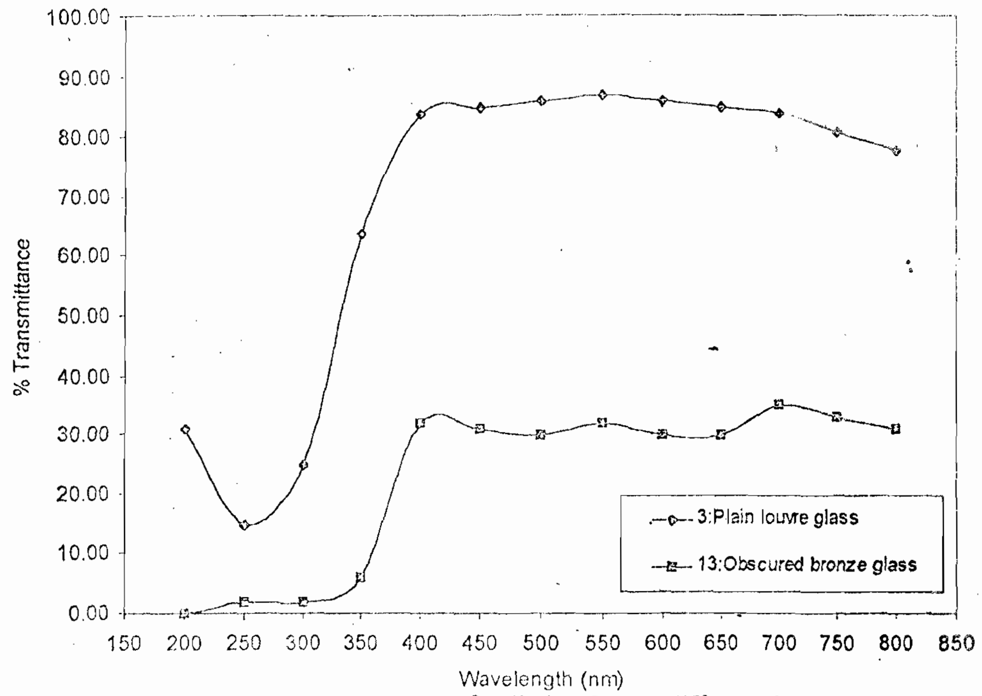

Fig. 9: Percentage Transmittance of radiation for two different glass specimens (3 and 13) with the same thickness of 4mm.

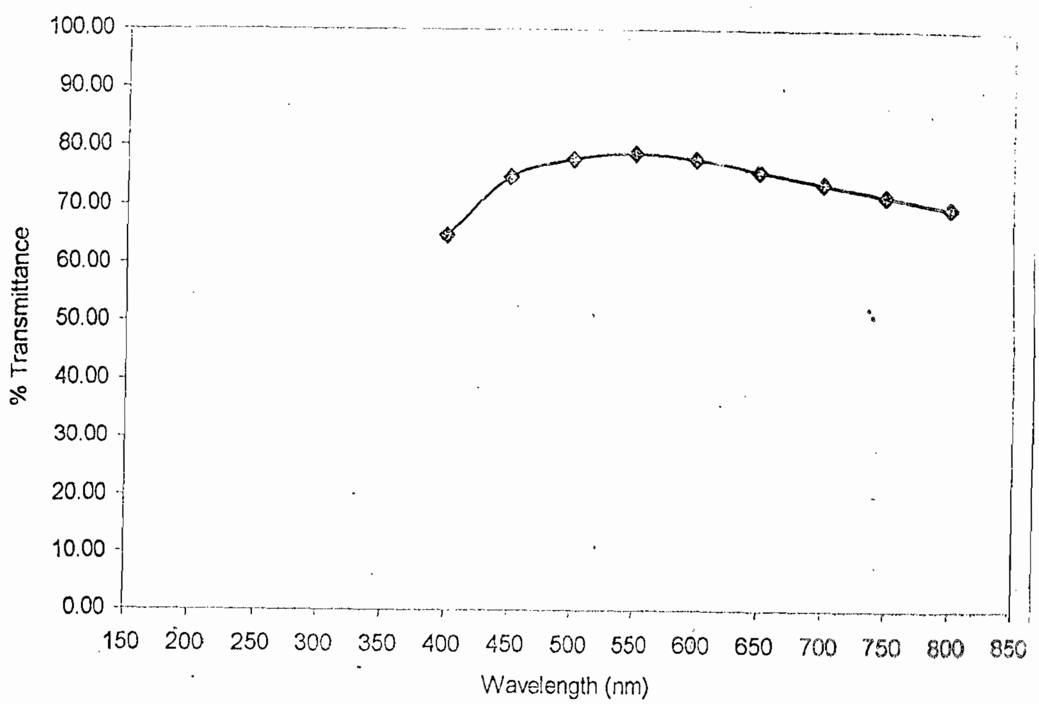

Fig. 10: Percentage Transmittance of radiation by Laminated glass (car windscreen, 6mm thick).

recommended for cooling in buildings. Finally, when plain glass sheets are applied to large storage tanks, long-term storage of thermal energy might become feasible.

REFERENCES

Al-Azzawi, S. and Yasin. F., 1985. Optical and chemical properties of glass with special reference to Building. Solar and Wind Technology 2 (1): 41 – 51.

Duffie, J. A. Beckman, W. A., 1974. Solar energy – thermal processes. Wiley, New York.

Eno. E. E. and Akpabio, L. E., 2000. Optical properties of glasses and selected Dyes with special reference to use in Windows. A presentation at the International Workshop on Condensed Matter, SHESTCO, Abuja: May 21 – 24.

Goetzberger, A., 1987. Potential uses of transparent insulation material for thermal collectors and in buildings. Solar and Wind Technology 4 (3): 389 – 393.

Holloway, D. G., 1973. The Physical Properties of Glass Wykeman, London.

Jones Jr, R. E., 1979. Effects of Overhang shading of Windows having Arbitrary Azimuth. University of Colorado, U. S.A.

Meinel, A. B. and Meinel, M. P., 1977. Applied Solar Energy (An Introduction). Addison – Wesley, Reading.

Shand, E. B., 1958. Glass Engineering Handbook, Mac Graw – Hill, New York.

Standworth, S. E., 1950. Physical Properties of Glass. Clarendon Press, London.

Twidell, J. W. and Weir, A. D., 1990. Renewable Energy Resources.

Weyl, W. A., 1959. Colured Glasses. Society of Glass Technology. Sheffield.