



# Evaluation of Solar Radiation Transmission through Window glasses and Transparent Facades for Buildings in Sulaimani

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## Abstract

In this work, we discuss the optical behavior of transparent materials used in Sulaimani for windows and in building facades such as fully transparent colorless and colored glass of different thickness in single and double- pane windows, a one way colored reflective glass window, as well as Tempered reflective glass. Ultraviolet, Visible and Infrared transmittance by these glasses is studied; the results are related to the visual comfort, heat transfer and health issues. Spectrophotometric analysis of the transmitted radiation is carried out at the proper incident of a wavelength range from 1200 nm to 190 nm, with steps of 1 nm. It is clear that attention should be paid to the quality of glass used for home and building facades to reduce visual strain, discomfort and avoid the risk of developing sun damages for our skin and its adversely affect for fabrics and furnishings.

**Keywords:** Optical properties, Ultraviolet spectrum, Infrared spectrum, Window Glass.

## تقييم نفوذ الاشعاع الشمس خلال نوافذ الشبابيك والواجهات الشفافة للمباني في مدينة السليمانية

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### المخلص

تم دراسة الخصائص البصرية لزجاج النوافذ وواجهات المباني المستخدمة في مدينة السليمانية بأنواعها المختلفة من الزجاج الشفاف عديم اللون و الملون، بسمك المختلفة وعلى شكل طبقة واحدة او طبقتين بينهما حيز من الهواء. إضافة الى الزجاجات العاكسة للضوء، والتي تعتم الصورفي الجانب الاقل الانارة. أما الزجاج المستخدم في الواجهات المباني يتميز بالتحول الى قطع صغيرة جدا بعد الكسر و لا يأذي المارة.

انجزنا التحليل الطيفي للأشعة النافذة بأجزائها المختلفة، الأشعة الفوق البنفسجية، المرئية و الأشعة تحت الحمراء ذلك من أجل تأمين الراحة البصرية، نقل الحرارة من والى داخل المنازل إضافة الى تأمين النواحي الصحية الناتجة عن نفوذ الأشعة الفوق البنفسجية. أنجزت التحليل الطيفي للأشعة النافذة في نطاق الطول الموجي من 1200 نانومتر الى 190 نانومتر بخطوات مساوية الى واحد نانومتر.

فمن الواضح أنه ينبغي إيلاء الاهتمام لنوعية الزجاج المستخدم لواجهات المنازل وبناء للحد من أجهاد البصري وعدم الراحة، وتجنب خطر الاصابة الجلد والأقمشة والمفروشات ناتجة من الشمس.

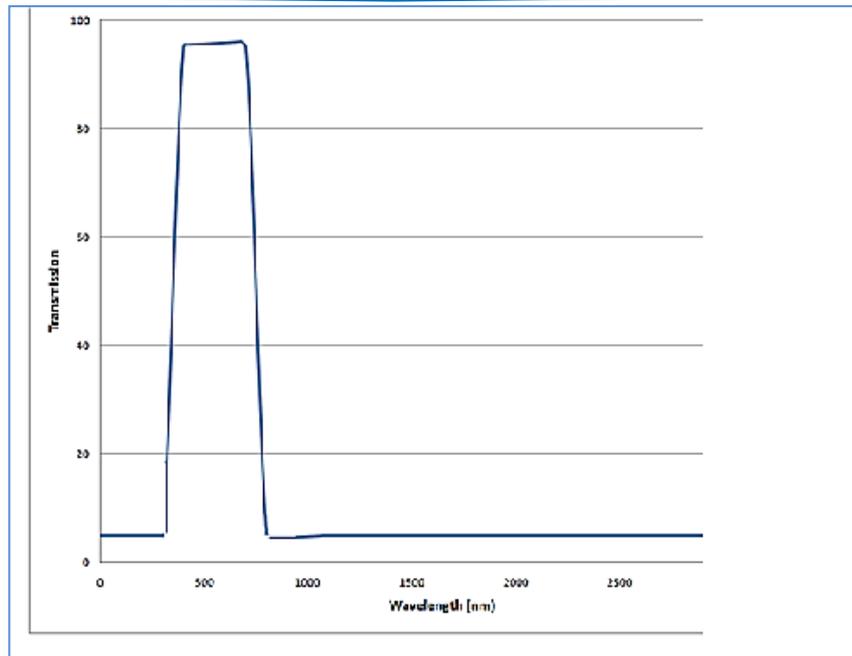
**كلمات دالة:** الخصائص البصرية، الطيف الفوق البنفسجي، الأشعة تحت الحمراء، زجاج النوافذ.

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## 1. Introduction

Regularly, when designing window glasses and transparent facades, technical data related to radiation transition for the solar spectrum are not available for study. The aim of this study is to discuss how the use of different glass types for windows can reduce heat transfer and ultraviolet transmission while maximizing light transmission, in turn, reduces the electricity used for space heating and cooling reducing energy consumption [1].

Sulaimani city has a semi-arid climate with hot, dry summers and cold, wet winters. The residents spend more than ninety percent of the average day indoors. For this reason, windows play a primary role of sunlight reaching an individual. During a summer day, solar radiation that reaches the earth consists of 55% infrared radiation in the interval (700nm-1mm), 42% visible light lies between (400 nm to700 nm) and 3% ultraviolet rays that lie in the wavelength range (290nm to 400nm). The divisions first proposed by the second International Congress on Light in 1932, it changed slightly due to biological effect of a different wavelength. The ultraviolet spectrum that reaches the earth's surface (290-400) nm consists of 96.5% UVA (320-400) nm which causes skin wrinkles, UVB (290-320) nm causes sunburn, and UVC(200-290) nm, although it possesses the highest energy and has the greatest potential for biological damage, is effectively filtered by the ozone layer and is therefore not considered being a factor in solar exposure of human beings [2-4]. People who spent significant indoor time near windows the parts of their bodies closest to the window showed the most exposure to UV radiation [5-7]. Skin cancer and cataracts are significant public health concerns. These diseases could be avoided by reducing exposure to solar UV [5-8]. Attention should be paid to the quality of glass used for office buildings, home windows, and building facades, to reduce solar gain, glare near windows, and avoid the risk for developing sun damages for our skin. [1] Two studies [9, 10] have reported the effectiveness of UV transmittance as a gauge of the window films efficacy. An ideal glass for the hot climatic condition, present optical characteristics like in Fig. (1).



**Fig. (1)** Ideal spectral transmittance for warm climates[1].

## 2. Materials and Methods

Measurements were done on the most widely used commercial glasses available in Sulaimani markets. First, samples were cut to a standard size of 2.5x2.5 cm and consisted of: 4mm, 6mm, 8mm and 10mm thickness colorless and brown glasses; 4mm, smoky white, blue and bronze reflective glass; one-way reflective green and blue glasses as well as Tempered reflective blue glass used for building facades, next the transmission measurements using Lambda 25, Ultra Violet and Visible Spectrometer were carried out at normal incidence in the wavelength range: 1200-190 nm with steps of 1nm, which yields 1110 measurements for each sample in the whole interval.

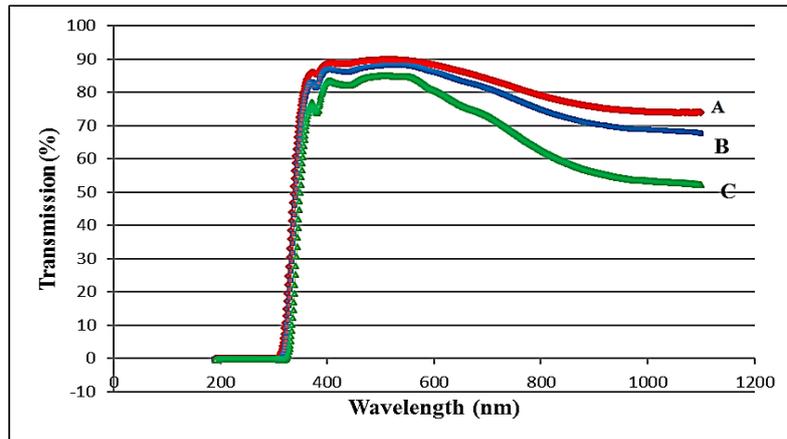
For the reflective glasses, both faces are taken as the incident face for the light since they are used alternatively by peoples even between rooms.

## 3. Results and Discussion

### 3.1 Colorless glasses

Transmission curves for the fully transparent colorless glasses **Fig. (2)** and **Table (1)**, shows that by increasing thicknesses the amount of UVA radiation transmitted decrease

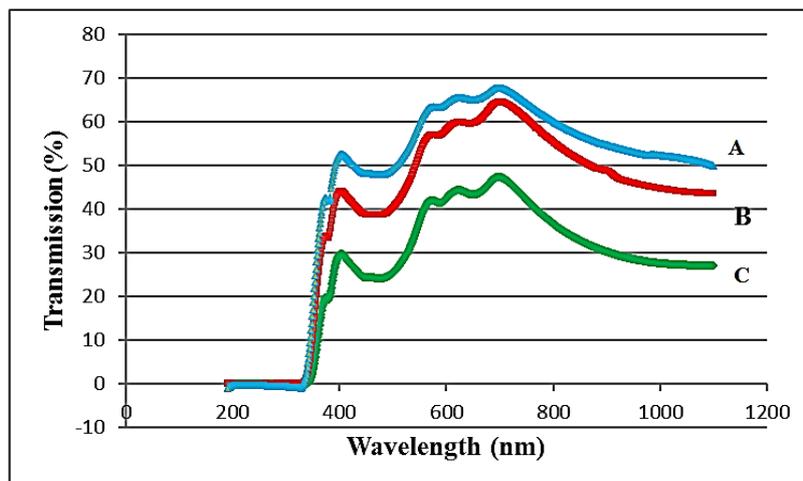
significantly, however, transmission of UVB is low it is also declining in the same manner. This reduction is observed for the visible light and the near-infrared radiation also, the attenuation is considerable in the near infrared region.



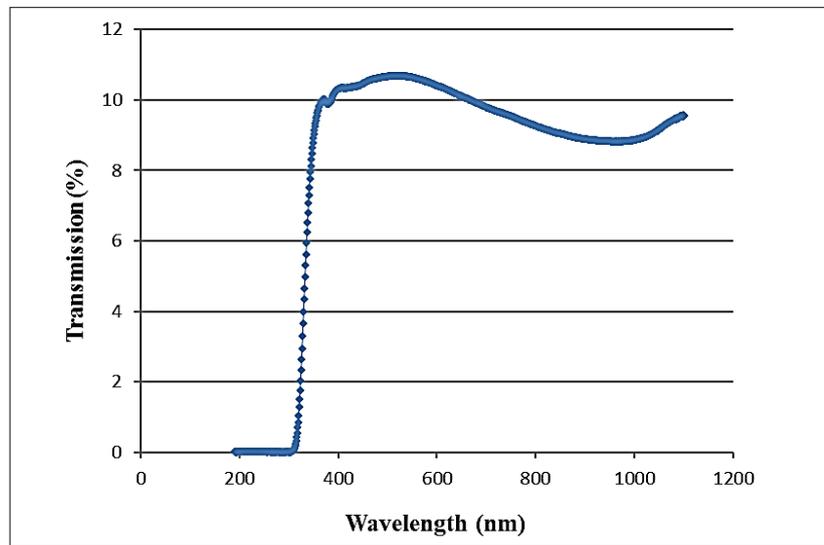
**Fig. (2):** Transmission curves for the colorless glasses of thicknesses A.4mm, B.6mm, C.10 mm.

### 3.2 Colored glasses

Brown and smoky white glasses, used for bathroom windows, are taken as samples to distinguish between their optical properties. Transmission curves for the brown glasses of thicknesses 4, 6 and 10 mm, are shown in Fig. (3). Attenuation of ultraviolet, visible, and infrared radiations for these glasses are more, about the uncolored glasses shown in Fig. (2) and Table (1), while the Smoky white glass transmission curve shown in Fig. (4) is preferable for use as windows, the results are shown in Table (1) also proves that.



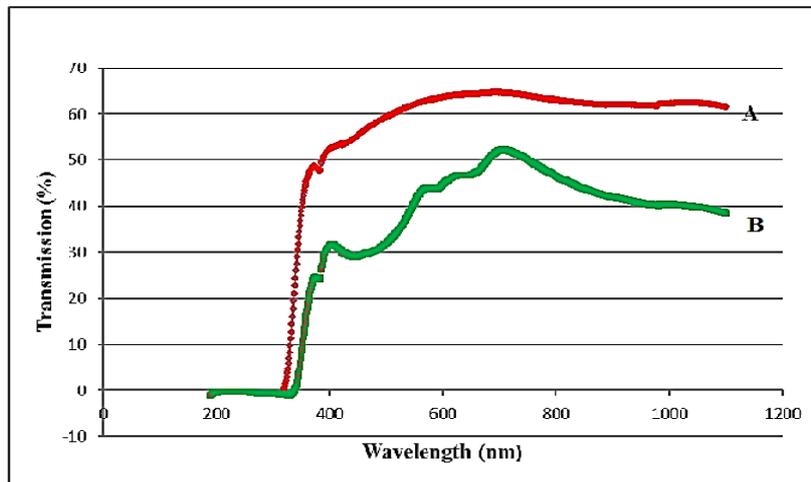
**Fig. (3):** Transmission curves for the colored(Brown) glasses of thicknesses A. 4mm B. 6mm C. 10 mm



**Fig. (4):** Transmission curves for the smoky white glasses of 4mm thicknesses.

### 3.3 Reflective glasses

Reflective glass has a special metallic coating that makes it possible to see out, while preventing people from seeing in, to preserve privacy during the day. Fig. (5) shows transmission curves for bronze and blue reflective glasses. The blue reflective glass presents almost the same transmittance of infrared and visible light. Relative to Fig. (1) this is not an ideal case. For the bronze reflective glass, a significant attenuation of the ultraviolet and near infrared radiation is observed. However, attenuation of the infrared radiation by the bronze glass is more pronounced. Bronze glass can be used alone but the blue glasses are used in double pane windows with the aim of shifting of the transmission curves toward the ideal case.



**Fig. (5):** Transmission curves for 4 mm A. Light blue glass B. Bronze reflective glass

### 3.4 Double-pane windows

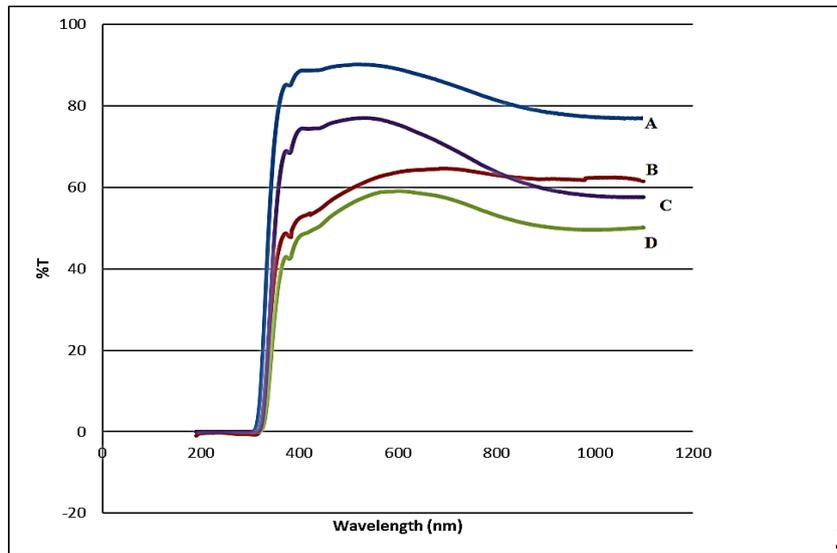
#### 3.5 Double-Pane Colorless Glasses

The double glazing window model used consists of two fully transparent 4 cm thick pans of glasses separated by a distance of 1cm. Fig. (6) shows the transmission curves of the above models used.

Curve A shows the transmission curve for an entirely transparent 4 cm thick window glass, curve C shows the transmission curve for two panes of the fully transparent 4 cm thick glass. This model is the same as the windows used at the University of Sulaimani. The intensity of the transmitted lights in curve C is reduced by, 20.19% for UVA, 1.31% for UVB, 13.44% for the visible light and 16.2% of the infrared radiation in comparison to curve A.

##### 3.5.1 Double-Pane Blue and Colorless Glasses

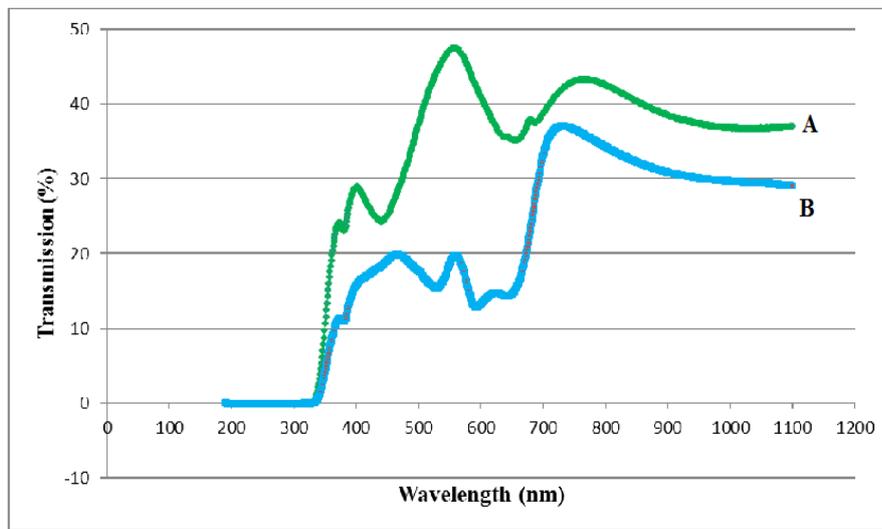
The transmission curve of the Blue and colorless glass in double-pane windows with its reflective pane outside is shown by curve D in Fig. (6), the difference between the transmission light intensities is as below: In model double-pane blue and colorless glasses, 20.15% of UVA, 0.07% of UVB, 18.05% of visible and 8.58% of Infrared radiation intensities are reduced, in comparison to model double-pane colorless glasses .



**Fig. (6):** Spectral Transmission curve for A. Fully transparent colorless glass, B. Blue reflective glass, C. Fully transparent colorless glass in double- pane window, D. Blue reflective and colorless glass in the double-pane window.

### 3.6 The One-way Mirror Glass

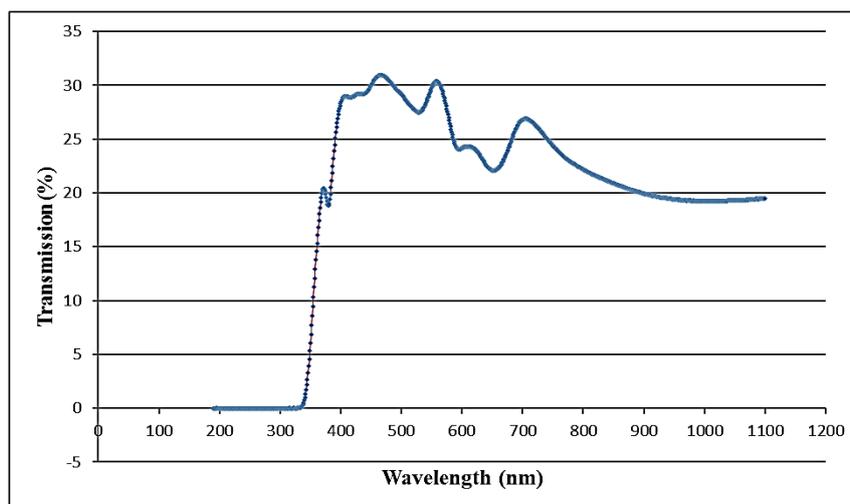
These types of window glasses are covered with a one-way film that can create a perfect mirror on one side of the glass so that transparency is kept on the other aspect of the window. Thus you can see everything while being yourself invisible. This glass is used for external windows, and in between the rooms, both faces are used. Transmission spectra of green and blue glasses are given in Fig. (7) A and B respectively. The One-way blue mirror glass transmits less visible light and rejects more near infrared radiation in comparison to the green mirror glass as it is seen in Table (1).



**Fig. (7)** Transmission curves of colored One-way Mirror Glass A. Green glass B. Blue glass

### 3.7 The tempered glass

The tempered glass is unyielding and used for facades, if it breaks it will break into small pieces like stone, it is ideal for reducing the chance injury in the event of breakage, **Fig. (8)** and **Table (1)** show that the blue tempered glass present a very low transmission of the near infrared radiation, despite its low transmission of visible light, it is still regarded suitable in hot climates because it is used in the front walls with large surface areas.



**Fig. (8)** Transmission curves of blue tempered glass

**Table (1):** Transmission through the glasses for normal incident light

Sample	Thickness (mm)	%UV		Vis. (%)	IR (%)
		UVA	UVB		
Colorless Glass	4	70.45	1.4	87.71	76.2
	6	63.49	0.07	85.25	71.03
	10	53.45	0.32	79.91	56.9
Colored Glass (Brown)	4	26.62	0.75	59.2	55.23
	6	20.63	0.01	52.52	48.87
	10	11.72	0.01	36.87	31.12
Colored Glass (White)	4	8.35	0.165	10.32	9.10
Reflective Glass (Light blue)	4	37.18	0.58	61.37	62.61
Reflective Glass (Bronze)	4	14.86	0.76	41.15	42.57
Double-Pane Colorless Glasses	4-4	50.26	0.09	74.27	60.33
Double-Pane Blue and Colorless Glasses	4-4	30.11	0.02	56.22	51.8
One-way Green Mirror Glass	4	15.15	0.0109	36.6	39.36
One-way Blue Mirror Glass	4	6.82	0.0127	17.34	32.12
Tempered Blue Reflective Glass		12.46	0.0014	27.12	21.13

#### 4. Conclusion

1. The results match the results of [1-2].
2. The brown colored glasses of different thicknesses possess acceptable transmission curves attenuation, due to the variation of the glass thicknesses, take place in the near infrared and visible light regions. While the opaque white glass of 4mm thickness is preferable for bathroom windows.
3. Although the double pan arrangements for the used models shift the spectral transmittance of the single pans toward the ideal case, the single pan bronze reflective glasses also still perfect.



4. For all types of glasses that were studied, the tempered blue glass used for facades can be considered as that best fulfills the ideal conditions.
5. Those who spend most of their times in their homes or( indoor) have to be educated to sit as far away from the window as possible because the effect of UV light on the skin decreases with distance.

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