

Manuel F.R.P. Alves¹, Mariana R.F. Silva^{1*}, João P. Cunha¹, Cristina A.F. Silva², João L. Costa³, Paula M. Vilarinho¹, Paula Ferreira¹, Maria H.V. Fernandes¹

Presenting author: manuel.alves@ua.pt

¹CICECO- Departamento de Engenharia de Materiais e Cerâmica, Universidade de Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal.

² Superbock- Via Norte Aptd. 1044, 4466-955 Leça do Balio, Portugal.

³ Barbosa e Almeida Glass Group - Av. Vasco da Gama 8001, 4434-508 Avintes, Portugal.

Motive and Objectives

The soda-lime glass system is known to be chemically stable, relatively inexpensive, and extremely workable. These properties make the soda-lime system suitable for the industrial manufacture of high-volume products. Nevertheless, as most industrial grade glasses, the soda-lime system has poor absorption of ultraviolet (UV) light. UV-radiation has high energy and can induce photodegradation reactions on organic substances and polymeric materials, greatly reducing their lifespan. To deal with this issue, while keeping color neutrality, ions that are capable to absorb UV-radiation, such as those from the rare earth and transition metals groups, are usually added to the main composition. However, some glass compositions containing these ions are also reported to experience photochromism. This work aims to evaluate the impact of the ratio between CeO_2 and V_2O_5 on the UV-shielding and photochromic behavior of soda-lime glasses.

Methodology



1. Glass fusion

2. UV-A exposure (Lamp = 356 nm)

3. UV-Vis spectroscopy + Colorimetry (CIELAB color space)

4. Fast heat treatment at T_g for recovery the original color

5. UV-Vis spectroscopy + Colorimetry (CIELAB color space)

Results and Discussion

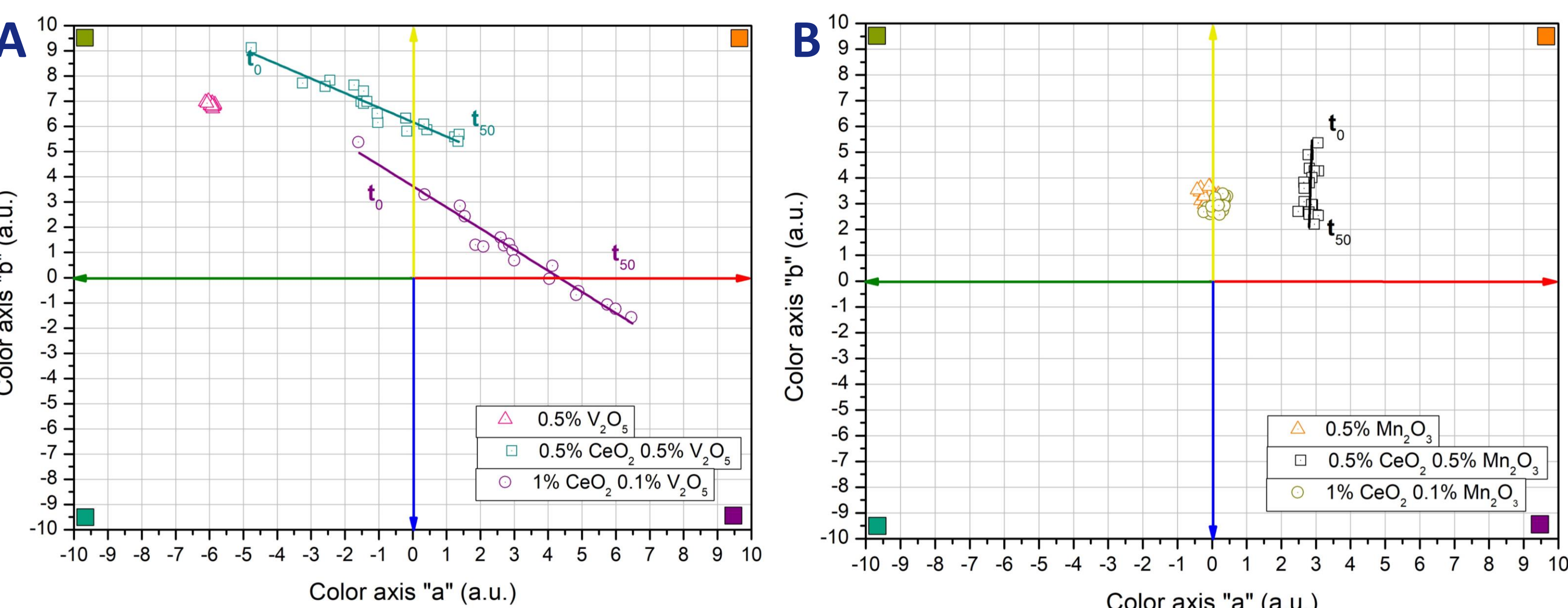


Figure 1 – A: ΔE values of all samples with vanadium oxide (0-45h) B: ΔE values of all samples with manganese oxide (0-45h)

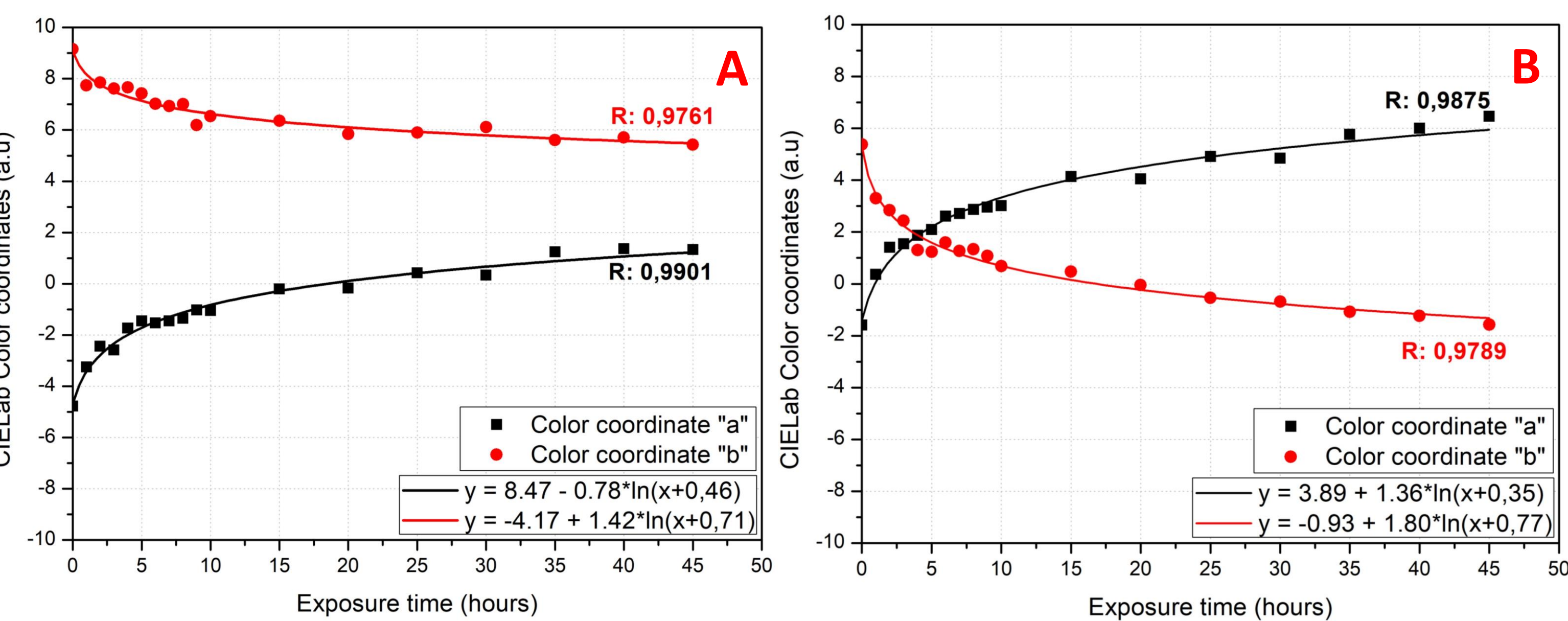


Figure 2 – CIE Lab coordinates, where: A: $0.5 \text{ CeO}_2 + 0.5 \text{ V}_2\text{O}_5$ and B: $1 \text{ CeO}_2 + 0.1 \text{ V}_2\text{O}_5$. The data has been modeled using a three-parameter logarithm function.

Sample	T=0	T=25h	T=45h	Thermally Recovered
$0.5\% \text{ Mn}_2\text{O}_3$				
$0.5\% \text{ Mn}_2\text{O}_3 + 0.5\% \text{ CeO}_2$				
$0.1\% \text{ Mn}_2\text{O}_3 + 1\% \text{ CeO}_2$				
$0.5\% \text{ V}_2\text{O}_5$				
$0.5\% \text{ V}_2\text{O}_5 + 0.5\% \text{ CeO}_2$				
$0.1\% \text{ V}_2\text{O}_5 + 1\% \text{ CeO}_2$				

Table 1 – Photos of the glass samples at different exposure times, showing the color change and color recovery after a brief (30 min) thermal treatment at T_g .

Conclusions and future work

With this work we found that:

- All glasses containing CeO_2 - V_2O_5 presented a perceptible color variation after exposure to UV-A radiation; $\Delta E > 14$;
- Equations to describe the kinetics of the photochromic effect have been modeled with good agreement ($R > 0.98$);
- The rise of the band centered at 540 nm, on the UV-Vis spectra, suggests the presence of V^{2+} species, which is coherent with the observed color change;

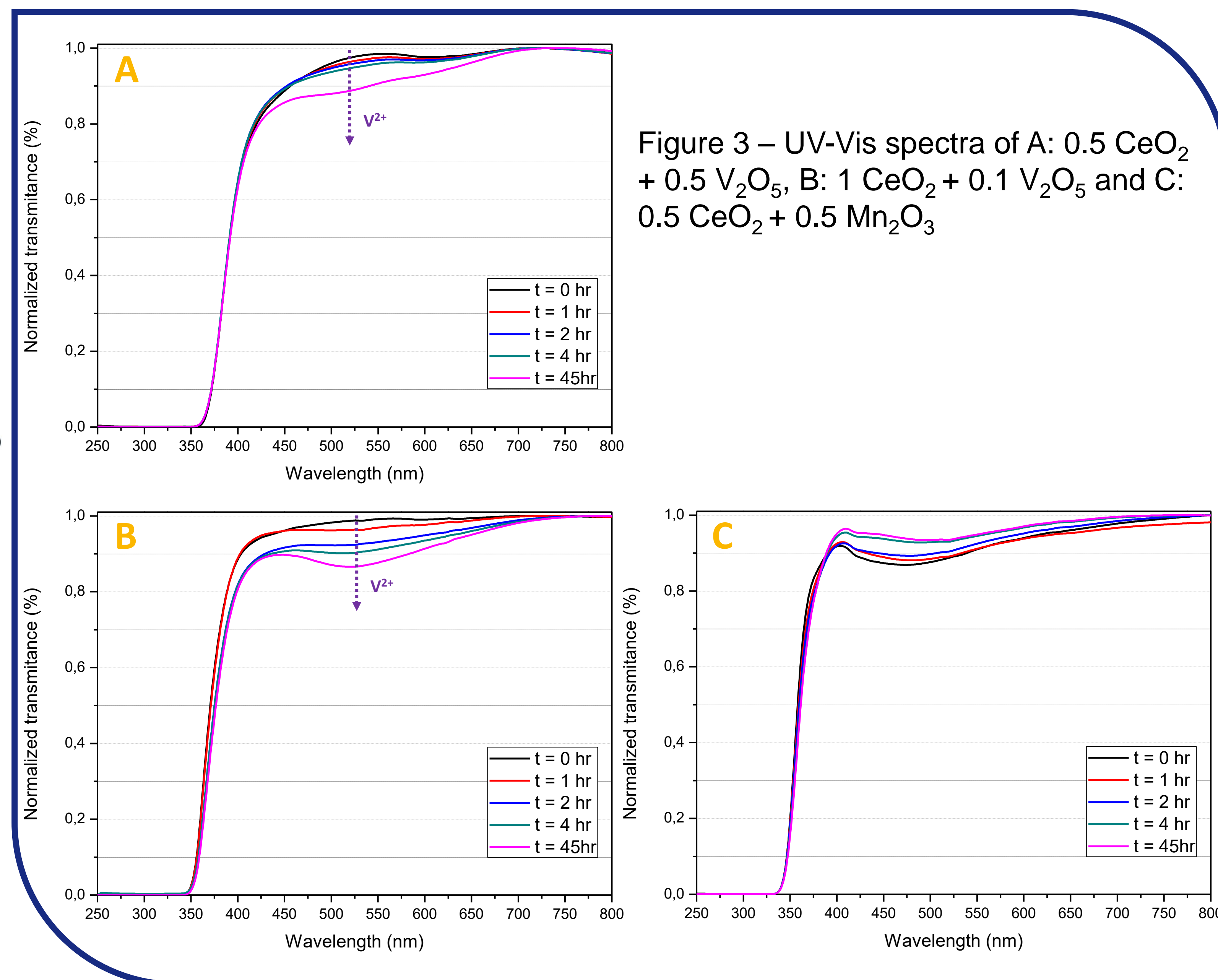


Figure 3 – UV-Vis spectra of A: $0.5 \text{ CeO}_2 + 0.5 \text{ V}_2\text{O}_5$, B: $1 \text{ CeO}_2 + 0.1 \text{ V}_2\text{O}_5$ and C: $0.5 \text{ CeO}_2 + 0.5 \text{ Mn}_2\text{O}_3$

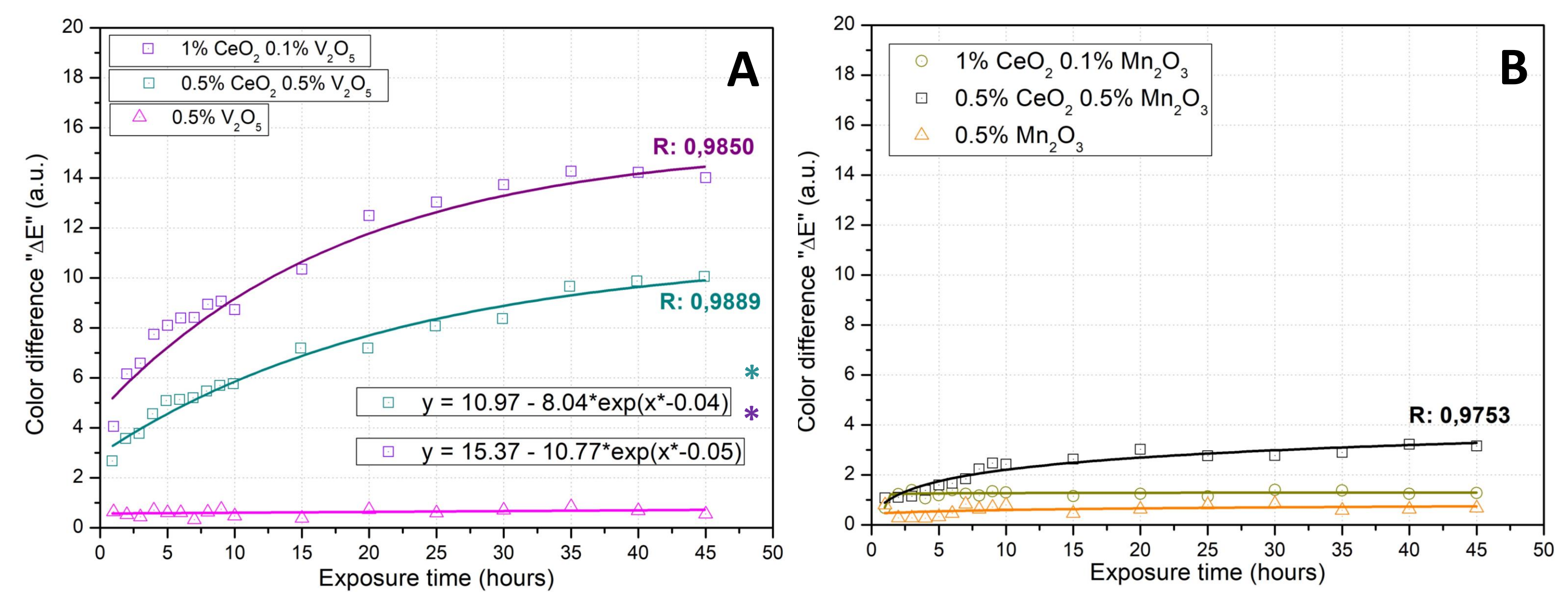


Figure 4 – Evolution of the color difference (ΔE) due to the exposure time to UV-A radiation, where: A: glasses containing CeO_2 and V_2O_5 ; B: glasses containing CeO_2 and Mn_2O_3 . The measured data has been modeled using an exponential function. The recovered samples have been identified as “*”.