

Luminescent Glasses with Ultraviolet LED's and Solar Energy Capture

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The main purpose of this research is the production of glass art involving the synthesis of borosilicate luminescent glass and UV LED technologies. We have an ongoing financed project (PTDC/EAT-AVP/118520/2010) and some results concerning the use of luminescent glasses in artworks were already published. One important part of this project was the development of luminescent borosilicate glass compatible with the Schott-Duran industrial glass, however soda-lime silicate glasses with different luminescent colours were also prepared. Several experiments using Eu_2O_3 , Sm_2O_3 , Tm_2O_3 , Dy_2O_3 and Tb_4O_7 oxides were made and the samples produced are being tested. Concerning the luminescent borosilicate glass synthesis, using a composition similar to the one used by Schott-Duran, it was observed the presence of several bubbles in the lanthanide doped glasses. Adding a fining agent, it was possible to obtain a luminescent borosilicate glass without bubbles and with a coefficient of thermal expansion very similar to the coefficient of Schott-Duran uncolored glass.



Figure 1 – Glass artworks made with luminescent borosilicate glass doped with different lanthanide oxides under UV-light (ca. 370 nm); Cesare Toffolo (2013).

The synthesized luminescent glasses were already applied in art works. In Figure 1 are presented some artworks made by the Glass Master Cesare Toffolo from Murano. This work was presented in an international conference in Venice entitled “Higher Studies on Venetian Glass”.

Borosilicate glasses doped with different Eu_2O_3 concentrations were synthesized to study the lanthanide influence in the glass structure, if europium behaves as a net former or as a net modifier. Spectroscopic and structural studies are being performed.

Some experiments were also made concerning the production of gold ruby borosilicate glass. Chloroauric acid was added to different borosilicate compositions, however more experiments are going to be performed, because the red colour was still not obtained.

Another part of this project consists in the development of UV LEDs to create artworks that are luminous from within. Art sculptures in luminescent glass were already produced by blowing, kiln-casting, fusing processes and lampworking and will be illuminated by internal UV LED sources. In Figure 2 is presented an experiment made with europium doped borosilicate glass illuminated with a 365 nm UV LED.

Solar panel energy capture will be one of the processes of powering the artwork. This task involves the specification, design and manufacturing of the electronic system needed to control the LEDs used in the artwork. The electronic system should be able to harvest energy from a solar panel, store this energy in a battery and then use this energy to power the UV LEDs used in the art-work. Since different artists should use the system in distinct art installations, it must be flexible enough to accommodate the different needs.



Figure 2 – Result of an experiment made with europium doped borosilicate glass (lampwork); Robert Wiley (2012). In this case a 365nm UV LED was placed under the object.

This work gave rise to several publications, communications and also part of the work made in this project was used in a PhD thesis.

Publications:

- Andreia Ruivo, Suzana M. Andrade, João Rocha, César A.T. Laia and Fernando Pina, "Formation of photoluminescent lead bromide nanoparticles on aluminoborosilicate glass", *Journal of Physical-Chemistry C*, (2014) DOI: 10.1021/jp5003758.

- Andreia Ruivo, Vânia S. F. Muralha, Hugo Águas, António Pires de Matos and César A.T. Laia, "Time-resolved luminescence studies of Eu^{3+} in soda-lime silicate glasses", *Journal of Quantitative Spectroscopy & Radiative Transfer*, 134 (2014) 29-38.

- António Pires de Matos, Robert Wiley, Magda Troeira, Carlos Queiroz, Andreia Ruivo, Nuno Paulino, César Laia. "Venetian Glass in Contemporary Art" at Higher Education Course - Study Days on Venetian Glass: Approximately 1600's, *Proceedings*, ed. By R. Barovier and C. Tonini in *Istituto Veneto di Scienze Lettere ed Arti* (2014) 177-181.

- Andreia Ruivo, Teresa Almeida, Fernando Quintas, Robert Wiley, Magda Troeira, Nuno Paulino, César A.T. Laia, Carlos A. Queiroz and António Pires de Matos. "Colours of Luminescent Glasses for Artworks" at 12th International AIC Colour Congress, Proceedings, ed. by L. MacDonald, S. Westland e S. Wuerger (2013) 885-888.

Oral Communications:

- António Pires de Matos, Robert Wiley, Magda Troeira, Carlos Queiroz, Andreia Ruivo, Nuno Paulino, César Laia. "Venetian Glass in Contemporary Art", talk at: Higher Education Course - Study Days on Venetian Glass: Approximately 1600's, Instituto Veneto di Scienze, Lettere ed Arti; 27th-28th Feb. & 1st March 2013, Venice.

Poster Communications:

- Andreia Ruivo, António Pires de Matos, Catarina Silva, César Laia, Fernando Quintas, Luisa Botelho, João Coelho, Pedro Santos, Robert Willey, Rui Silva, Teresa Almeida. "New materials and Techniques for artists", Annual Meeting of The Glass Art Society, Toledo, Ohio, June 13-15, 2012.

- Magda Troeira, Andreia Ruivo, Carlos A. Queiroz, António P. de Matos. "Emission spectra and dilatometric coefficients of lanthanide doped borosilicate glasses", Materials 2013, Coimbra, Portugal, 25-27 March 2013.

- Andreia Ruivo, Teresa Almeida, Fernando Quintas, Robert Wiley, Magda Troeira, Nuno Paulino, César A.T. Laia, Carlos A. Queiroz, António Pires de Matos, "Colours of Luminescent Glasses for Artworks, 12th International AIC Colour Congress", Newcastle, 8-12 July 2013.

PhD Thesis:

- A. Ruivo, PhD thesis in Sustainable Chemistry, "Synthesis and characterization of innovative luminescent glasses for artistic applications", Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, December 2013.