Novel approaches to ultraviolet radiation protecting thin films based on nanoparticle multilayers

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Herein we introduce a novel porous one-dimensional photonic crystal with strong reflectance in the ultraviolet (UV) region of the electromagnetic spectrum. These periodic nanostructures are built by spin-coating assisted layer by layer deposition of colloidal suspensions of non UV absorbing nanoparticles of ZrO_2 and SiO_2 (electronic band gap at λ<220 nm). The UV shielding effect takes place totally from optical interference phenomena and is related with the number of deposited layers and the difference of the refractive index values of the two materials that form the unit cell. Interference filters are designed consequently to block specific wavelength ranges in UVA, UVB and UVC regions of the electromagnetic spectrum. In addition, we show that the accessible pore network of the as-deposited multilayer allows preparing flexible, self-standing, selective UV filters without losing considerably reflectance intensity, i.e., preserving the dielectric contrast. We prove that these films outperform layers of similar thickness made of only absorbing materials in terms of the degree of radiation protection achieved.

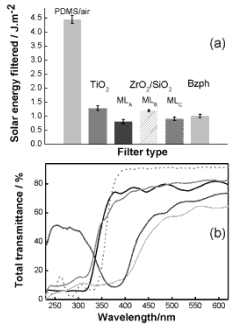

Figure 1: (a) Energy received by identical UV sensitive strips covered with different flexible protective films. Height of the bar represents the media value, black line represents the standard deviation. MLA , MLB , MLC belong to different ZrO_2 /SiO_2 films. (see figure 6b)(b) Total transmittance spectra of the protecting films used in Figure 6a. TiO_2 (black solid line), MLA (light gray solid line), MLB (grey solid line), MLC (dark grey solid line),benzophenone-3 (grey short dashed line).

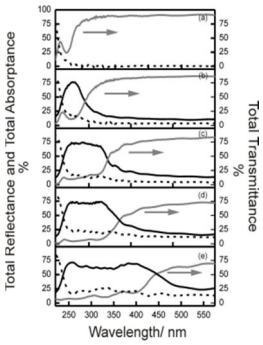

Figure 2: Total reflectance (black solid line), total transmittance (grey solid line) and absorptance (black dotted line) spectra of stacking flexible films prepared from samples shown in figure 4a. The number of stacking samples is 1 (a), 2 (b), 3 (c), 5 (d) and 7 (e). (black solid line), MLA (light gray solid line), MLB (grey solid line), MLC (dark grey solid line),benzophenone-3 (grey short dashed line).

References

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[2] M.E. Calvo, H. Miguez, Chem. Mater., 22, (2010), 3909–3915.