Photocatalytic and thermochromic materials applied to road engineering

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1. INTRODUCTION

Materials Science knowledge has been applied to Civil Engineering to provide new capabilities and benefits for the environment and society. Through the functionalization process with nano/microparticles, Civil Engineering materials can become smart. This study presents the main results of the research work with photocatalytic (nano-TiO_2) and thermochromic (Leuco dye) materials on road pavements and road markings [1-5].

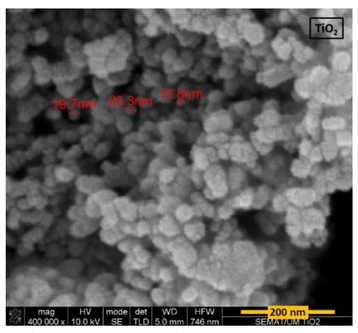


Figure 1. Nano-TiO_2

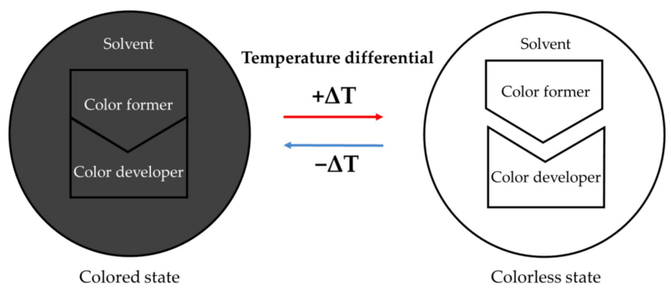


Figure 2. Thermochromic material Leuco dye

2. METHODOLOGY

Techniques used for the functionalization of the substrates.

Figure 3. Surface spray coating

Figure 4. Mass incorporation

3. PHOTOCATALYTIC MATERIALS IN ROAD PAVEMENTS

Figure 5. Setup for pollutant (Rhodamine B) degradation.

Anti-aging [1]

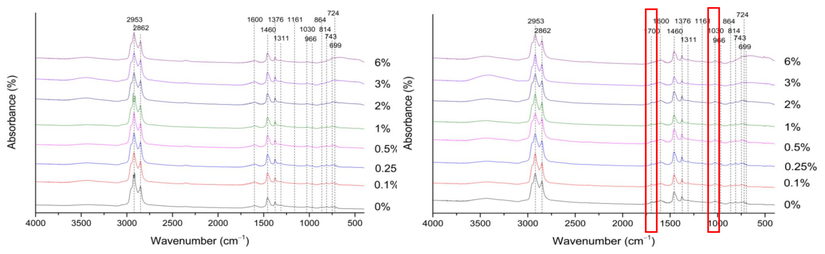


Figure 6. FTIR spectra of unaged (left) and aged (right) asphalt binder samples

Air-cleaning [2,3]

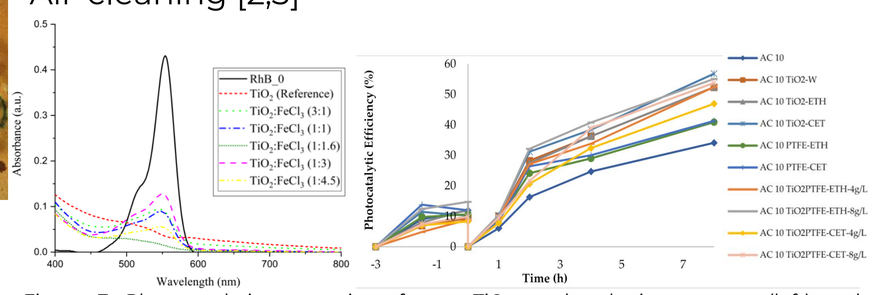


Figure 7. Photocatalytic properties of nano-TiO_2 under doping process (left) and functionalized asphalt mixture (right)

4. PHOTOCATALYTIC MATERIALS IN ROAD MARKINGS

Figure 8. Setup for pollutant (Methylene Blue) degradation

Self-cleaning

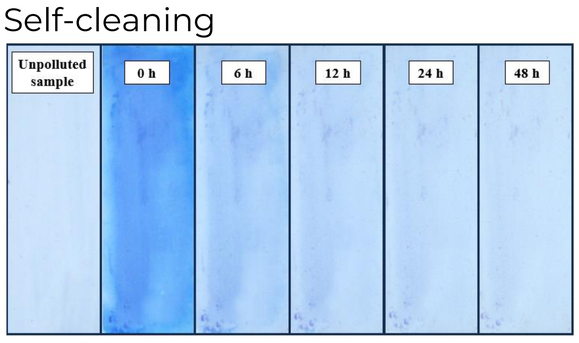


Figure 9. Road paint sample submitted to pollutant and irradiated over time

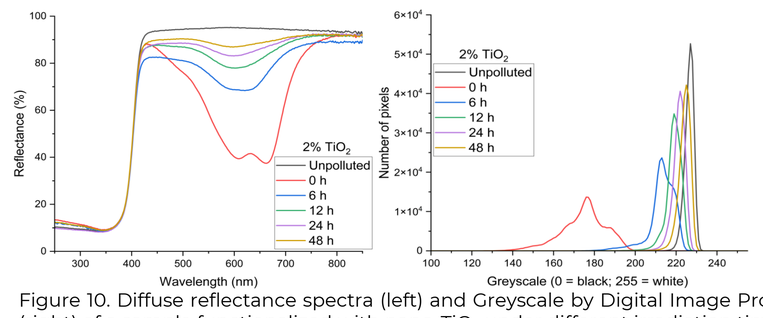


Figure 10. Diffuse reflectance spectra (left) and Greyscale by Digital Image Processing (right) of a sample functionalized with nano-TiO_2 under different irradiation times

5. THERMOCHROMIC MATERIALS IN ROAD PAVEMENTS

Urban Heat Island mitigation [4]

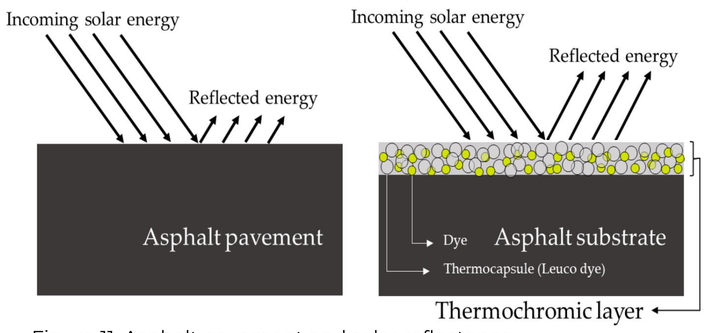


Figure 11. Asphalt pavement and solar reflectance

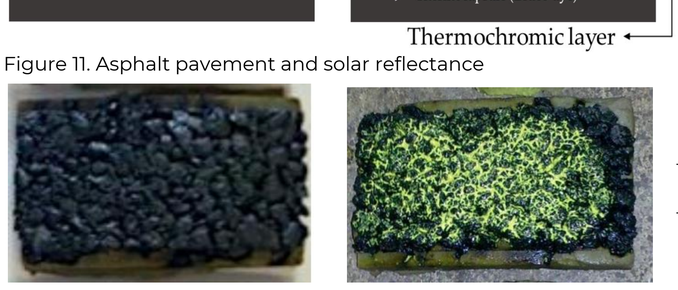
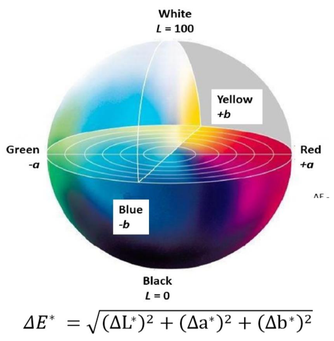


Figure 13. Reference asphalt mixture (left) and thermochromic asphalt mixture (right)



$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Figure 12. Color space by Comissione Internationale de l' Éclairage

Table 1. Colorimetry test

Color coordinate	Thermochromic asphalt mixture
ΔL*	4.69
Δa*	1.62
Δb*	4.5
ΔE*	8.66

6. THERMOCHROMIC MATERIALS IN ROAD MARKINGS

Color-based sensor for ice detection [5]

Figure 14. Functioning of the thermochromic road paint

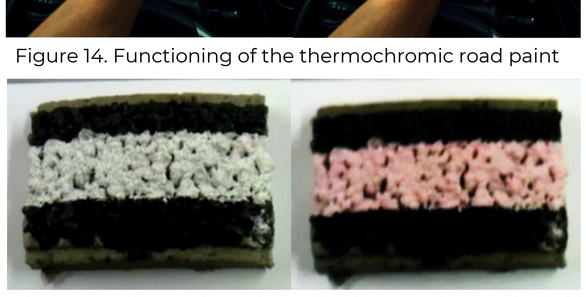


Figure 15. Thermochromic road paint sample at 25 °C (left) and 1 °C (right)

Scan here:

7. CONCLUSIONS

The results of work on photocatalytic materials pointed to:

- Higher efficiency of the semiconductor after the doping process;
- Photocatalytic efficiency of the asphalt mixtures functionalized with nano-TiO_2 at least 38% higher than the conventional ones;
- Reduction of the peak indicator of pollutant on the road markings up to 29% higher the non-functionalized samples in the first 6 hours of irradiation.

For the thermochromic materials, the color change ability and its reversibility were verified in both substrates after functionalization.

8. REFERENCES

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