Ecological, Photocatalytic, Superhydrophobic and Self-Cleaning Asphalt Pavement Surfaces

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Abstract

The aim of this research is to develop multifunctions on recycled asphalt mixtures for the surface layer of road pavements. Therefore, preliminary research on functionalization has been carried out. Afterwards, the asphalt mixtures were designed and characterized by mechanical and superficial point of views. The next step is the design of the nanomaterials, their application on asphalt mixtures and the characterization from physical, mechanical and superficial behavior.

Keywords. Photocatalysis, Superhydrophobic, Self-Cleaning, Surface Characteristics, Recycled Asphalts Mixtures.

1. Introduction

Currently, there is a growing concern about pollution and environmental damage. The surface layer of road pavements, besides being viable from the mechanical technical point of view, must have appropriate characteristics in terms of comfort, road safety and be sustainable (Noyce et al. 2005). The integration of nano/microparticles in Hot Mix Asphalt (HMA) provides new capabilities (functionalization) such as: photocatalytic, to photodegrade pollutants for the purpose of air cleaning; superhydrophobic, to improvement road safety; self-cleaning, to avoid slipping problems (Nahvi et al. 2018; Hassan et al. 2012). This research aims to design a multifunctional recycled HMA for the surface layer of road pavements with these capabilities.

2. Preliminary Research

A preliminary research was essential to combine the concepts of Civil Engineering and Physics. For this, two Hot Mix Asphalt mixtures (HMA), AC 6 and AC 14, were functionalized by volume incorporation of nano-TiO_2, and spraying coating a nano-TiO_2 and/or micro-ZnO aqueous solution. Their materials were characterized by Atomic Force Microscopy (AFM), Fourier Transform Infrared Spectroscopy (FTIR), and the mixtures were characterized by Water Sensitivity (WS), Permanent Deformation (PD), Fatigue Resistance (FR), Water Contact Angle (WCA) and photocatalytic efficiency.

2.1. TiO_2 and/or ZnO semiconductors particles on AC 14 and AC 6 HMA

The superhydrophobic property was developed for AC 14 TiO_2, AC 14 TiO_2 ZnO and AC 6 TiO_2 ZnO by spraying coating. The best photocatalytic efficiency was achieved for AC 14 TiO_2 ZnO.

2.2. Semiconductors Influence on Mechanical, Superficial and Photocatalysis

The WS of the HMA functionalized by volume incorporation reduced. Before abrasion, the photocatalytic efficiency was higher for the spraying coating technique than for the volume incorporation, while after abrasion, it was the opposite. Furthermore, the functionalization techniques conducted to a difference in friction between -7% and 3%.

3. Materials and Methods

AC 10 Surf Elaster 13/60 was decided to proceed the research after the analysis of the preliminary results. AC 10 was designed without recycled materials and with 30% of Reclaimed Asphalt Pavement (RAP) and Steel Slags (SS). The HMA were evaluated by the mechanical and superficial tests. TiO_2 activates only with UV-light with a band gap of about 3.20 eV. To activate it on visible light (doping), a first approach was carried out using urea by ball milling technique. The powders were characterized by FTIR and diffuse reflectance spectroscopy.

4. Results

4.1. HMA Characterization

The HMA were mechanically characterized by WS, PD, FR, and functionally by friction, macrotexture, mechanical impedance, sound absorption. Considering the both characteristics, the best recycled HMA was the one with Steel Slags.

4.2. TiO_2 doping

In order to reduce the band gap (activation energy) of the semiconductors, nano-TiO_2 was mixed with urea by the ball milling technique, variating the percentages, rotation speeds and also time. The minimum band gap achieved was 2.97 eV, corresponding to the visible light violet. Other techniques and approaches will be carried out in order to ensure the doping.

4.3. Aging Resistance of Asphalt binder containing TiO_2

Asphalt binder oxidizes due to temperature and weathering. A first approach was carried out considering the standard oxidation tests, Rolling Thin Film Oven Test (RTFOT) and Pressure Ageing Vessel (PAV) to assess aging on modified bitumen with nano-TiO_2. The modified asphalt binders showed improved the aging resistance. The next step will be the characterization of the binders by UV light oxidation.

5. Conclusions

This research aims to design a multifunctional recycled HMA for the surface layers. The recycled HMA were designed. The semiconductors materials are being mixed with other materials for doping. The asphalt binders with the capability to resist better to aging were designed. The next step of this research is the improvement of the doping, and the application of the nano/micromaterials by other techniques, for example, using resins or even electrostatic painting. The new capabilities and the essential characteristics will be evaluated.

References

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