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Real scale application of visible light responsive photocatalytic paints for indoor air quality

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Abstract

In the frame of a LIFE19 project named "VISIONS", an innovative photocatalytic paint was produced for healthy environment and energy saving purposes. To that end a photocatalytic powder was optimized in order to be mixed in paints without downgrading paint physical properties and to reduce production cost. The photocatalytic efficiency of the powder as well as the VISIONS photo-paints was evaluated in both lab and real scale applications. Lab-scale tests were performed in a continuous tank reactor in order to quantify the capacity of VISIONS photo-paints to degrade photocatalytically inorganic (nitrogen oxides NOx) and volatile organic (VOCs e.g toluene) air pollutants under both Visible and UV irradiation. Real-scale tests took place in Demo-houses (picture 1) and currently in the Hellenic Naval Academy building where VISIONS photo-paints are monitored with regards to Indoor Air Quality (IAQ) improvement and reduction of energy consumption.

Keywords: photocatalytic paint, Indoor Air Quality

1. Introduction

Indoor air pollution can be addressed through the two approaches of prevention and removal. The latter includes the use of air cleaning technologies such as filtration and adsorption, electrostatic air purification, air filtration and gas adsorption filtration, ozonation and photocatalytic oxidation. Air cleaning photocatalytic technology is based on the principle that radiation of suitable wave-lengths can be absorbed by semiconductors, which leads to the creation of reactive oxygen species that can degrade air pollutants. TiO2 is the most commonly-used semiconductor in photocatalytic oxidation research. However, over the last years, scientists have combined TiO2 with other materials in order to enhance the photocatalytic oxidation degradation of air pollutants. Although photocatalytic technology is promising, the synthesis route of a photocatlytic material should be designed carefully in order to avoid contaminants which could lead to the formation and emission in the gas phase of intermediate products as they can be more hazardous than the target pollutant. The present research addresses the indoor air purification study using a photocatalytic paint, which was tested under both laboratory and real-world indoor conditions (application in Demo Houses). The experimental study of the current work was carried out using the European Committee for Standardization (CEN) Technical Specification (TS) 16980:2016 as a basic reference to perform the lab scale experiments, while the real scale experiments were based on the comparison between the concentration level of a pollutant in a reference and the "green" room, respectively.

Picture 1. Demo Houses: facility for testing building materials photocatalytic efficiency

2. Methodology

Real scale application of the VISIONS photo-paint took place in 2 Demo- Houses which are located on the premises of FORTH in Crete and comprise a unique European facility. The VISIONS photo-paints were applied on the surface of the interior area in one of the Demo-Houses (ceiling and walls approx. 37m^2) the so call "Green House". The other one was considered as reference: the "Conventional House". The two houses are separated by a control room where the monitoring equipment (NOx, O_3 and BTEX analyzers) were placed.

Both houses (Green and Conventional) equipped with 8 lamps (Philips 1200 mm, 18watt, LED Ecofit) which are emitted in visible spectra and the light intensity on the walls were measured 10.1 Btu/ft^2 h up to 11.3 Btu/ft^2 h. Furthermore, monitoring equipment coupled with data loggers continuously recorded concentration of NOx, O_3, and VOCs, temperature, RH% and light intensity were installed inside each 'house'. Houses were fed with air pollutants in order to achieve the required pollution level (close to real indoor conditions).

3. Results

By activating the photocatalytic building material (turn on the light) the pollution level in the 'Green House' was reduced up to 61.7% while in the conventional one up to 24.6% (Fig.1). All side effects (adsorption on walls, photolysis, photocatalysis etc) was also estimated. Hence, the feasibility of the photocatalytic building materials to reduce the air pollutants introduced in the Demo-House indoor environment were estimated through the comparison of the air quality levels in the two "houses".

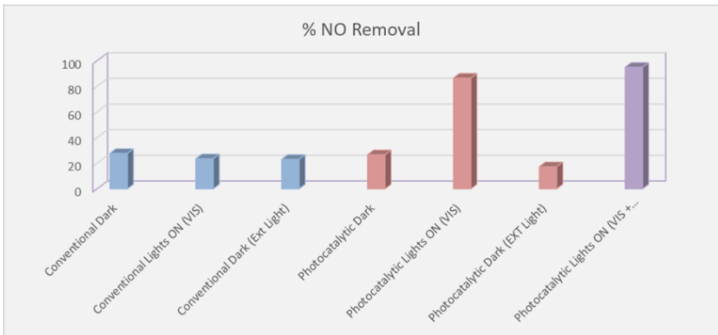

Figure 1. Nitrogen Oxide (NO) removal in Demo Houses under different photocatalytic conditions

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