MAK HILL Publications Journal of Engineering and Applied Sciences

Research Article
doi: jeas.2022.61.68

OPEN ACCESS

Key Words
Titanium dioxide, photocatalytic concert, air purification, eco-friendly materials

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Received: 25 September 2022
Accepted: 12 December 2022
Published: 27 December 2022

Citation: Arafa A. Abbass, Zeinab A. Elhassan, Faiga Magzoub and Mona D. Abdalrazig, 2022. Photocatalytic Concrete Environmently Materials to Improve indoor Air Quality. J. Eng. Appl. Sci., 17: 61-68 doi: jeas.2022.61.68

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Photocatalytic Concrete Environmently Materials to Improve Indoor Air Quality

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ABSTRACT
The primary findings of a study on the removal of nitrogen oxide (NOx) from concrete composite panels using air cleaning agents, such as titanium dioxide (TiO_2), are presented in this paper. Other factors that may have an impact on the studied blocks' properties include the porosity of the panels, the types of waste materials used in the mix design and the types and percentage of TiO_2 added. The initial findings demonstrate that the porosity of the panels has an impact on the photo degradation of NO. The panel's ability to eliminate NO improved along with its porosity. As a result, it's crucial to consider the aggregate's selection, size and composition while designing the mix. An ideal mix design was chosen, which contains recycled aggregate, cement and TiO_2, based on the basic experimental results.

INTRODUCTION

The health and well-being of humans depend on clean indoor air. About 90% of people's time is spent indoors. The health of those who spend the majority of their time indoors, such as the very young, the elderly and those who are chronically ill, is more affected by indoor air quality. Because indoor air warms up, it can become more contaminated than outdoor air; cooling and ventilation systems are frequent breeding grounds for bacteria. This essay discusses the value of using environmentally friendly concrete blocks for a variety of structures that can benefit from the reduction of nitrogen oxides (NO), which can pollute the air in developing nations, by using locally available waste materials. These advantages can occur when chemical materials are used in conjunction with other materials, such as toxic gases, to maximize their structural benefits and reduce their environmental impact.

The quality of indoor air received a great deal of attention during the start of the 1990s. An innovative method involves using nanotechnology to photocatalyze an enhanced oxidation effect on materials. Due to its intriguing characteristics including electrical, optical and UV absorption photocatalysis investigations, oxidation photocatalyst removes comparable (TiO_2) has gained significant interest in recent years. Anatase, rutile and brookite are the three primary crystalline phases of titanium dioxide and an earlier study found that anatase is the phase with the greatest photoactivity. As a result, numerous investigations on photocatalysis have paid particular attention to the crystalline form of anatase. Due to its strong photocatalytic activity, which is facilitated by the size of the particles in increasing the diffusion of excited electrons and holes towards the surface before recombination, high stability because electrons are inactive in the absence of illumination, non-toxicity, low cost and high oxidation capacity, anatase-sized nanocrystalline titanium dioxide is an ideal photocatalytic material[1]. As a result, it was determined that the nano-structured titanium dioxide photocatalyst was a promising catalyst for the microbial and organic contaminant decomposition. This could result in a variety of applications, including self-cleaning materials, water and air purification and environmental sterilization[1,2].

About 25 years ago, photocatalysis research was first conducted in the scientific community. Chemical substances that are among the most common in daily life, such titanium dioxide (TiO_2), have shown to be good photocatalyst materials for environmental remediation. This study discusses the most recent developments in the field of TiO_2 photocatalysis, particularly in photocatalytic air purification, sterilization and cancer therapy. The TiO_2 is used in an unique photoinduced superhydrophilic phenomena and its applications are discussed.

The problem statement of this document is: Pollutant levels within buildings are actually higher than outside and the construction industry is a significant contributor to air pollution. Also, people spend more than 80% of their time indoors, increasing the likelihood that they will breathe in pollutants compared to when they are outside. Figure 1 appearance The large density of automobiles at street level generates a lot of air pollutants, which are blocked and prevented from dispersing by numerous towering buildings . It is obvious that it is necessary to remove pollutants from the atmosphere, such as nitrogen oxides (NO) and sulfur dioxide (SO_2). These gases not only pose a health risk but also contribute to

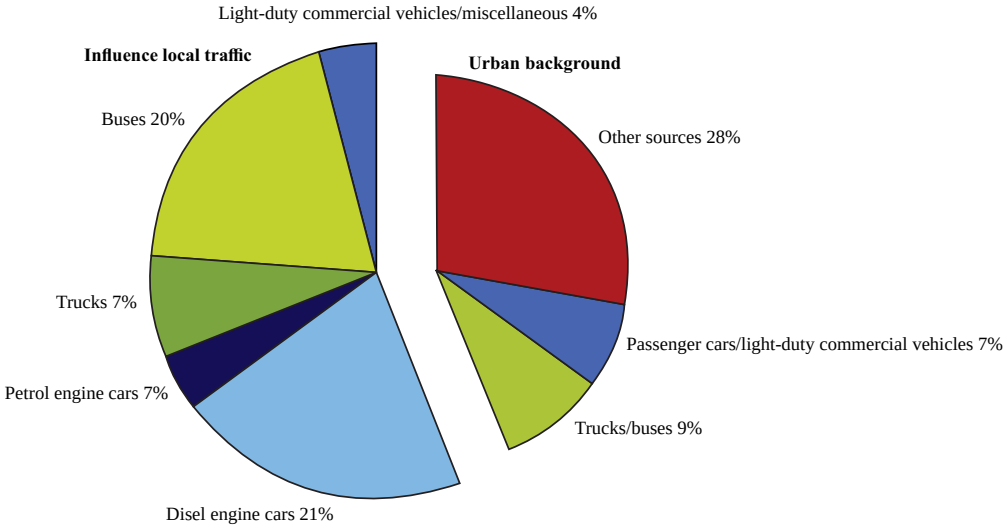

Fig. 1: Sources and NO_2-concentration at the traffic site[3]

the deterioration of many downtown buildings. The most practical way to improve interior air quality is to construct a local, inexpensive building panel system fit for their tropical region, despite attempts to limit these emissions by employing cleaner air using chemical materials, a means of eliminating pollutants from the atmosphere[2,4].

Phtotcatlatic process

Indoor air quality: Toxic air pollutants, also known as hazardous air pollutants, are pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive issues or birth defects, or adverse environmental effects. The EPA works with state, local and tribal governments to reduce the release of 187 air hazardous pollutants into the environment. Other dangerous air pollutants include benzene, which is found in gasoline, perchlorethlyene, which is discharged from some dry cleaning facilities and methylene chloride, which is used in many industries as a solvent and paint stripper. Other types of air toxics include dioxin, asbestos, toluene and metals like cadmium, mercury, chromium and lead compounds.

If people are exposed to dangerous air pollution for long enough lengths of time, they may be more prone to develop cancer or other serious health issues. In addition to neurological, reproductive (such as lower fertility), developmental, pulmonary and other health problems, the immune system may also be damaged. Certain dangerous air pollutants, like mercury, can settle on soil or surface waters and then be absorbed by plants, eaten by animals and then multiplied up the food chain. Together with that, there is also exposure from breathing intoxicants. Animals may have health problems comparable to those that impact humans if they are exposed to enough air toxics over an extended period of time[3].

Indoor air quality (IAQ) is concerned with the components of interior air that may have an impact on building occupants' health and comfort. Allergens, chemicals (such as carbon monoxide, radon), microbiological pollutants (mold, bacteria), or any mass or energy stressor that can have a negative impact on health can all damage the IAQ. Asthma is one of numerous health hazards linked to indoor air pollution. Albeit with different chemicals, recent research has shown that indoor air is frequently more contaminated than outdoor air, yet this hasn't altered how people typically think about air pollution.

In fact, indoor air frequently poses a worse threat to health than the similar outdoor environment. The main techniques for raising indoor air quality of most buildings are filtration, source control and ventilation to dilute pollutants. The IAQ analysis methods include taking air samples, taking samples from building surfaces and using computers to simulate how the air moves inside structures. Samples from the process can be examined for the presence of bacteria, chemicals, mold, or other stressors. These investigations can help identify the sources of the contaminants, which can then help develop removal techniques for the unwelcome substances in the air[4,5].

Chemical materials, titanium dioxide: The usefulness of applying air purifying agents like titanium dioxide (TiO_2) in the process of creating concrete paving blocks, using local waste materials to remove nitrous oxide, is examined in this work (NO). The porosity of the blocks, the type of waste materials utilized in the mix design and the types and percentage of TiO_2 incorporated within the mix design are some of the factors that were investigated in order to determine how the blocks would function (Fig. 2).

See Inside the outcomes demonstrate that the porosity of the blocks in Fig. 3 has an impact on the

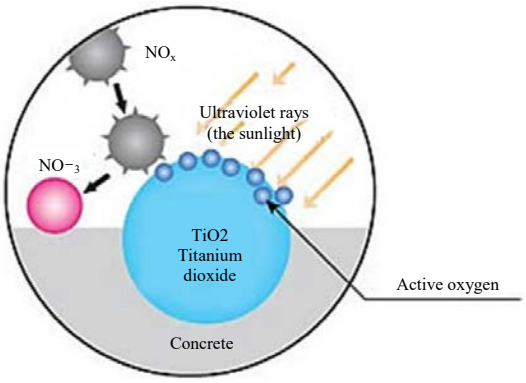

Fig. 2: UV-activated photocatalytic titanium dioxide speeds up the breakdown of airborne pollutants like nitrous oxide (NOx)[6]

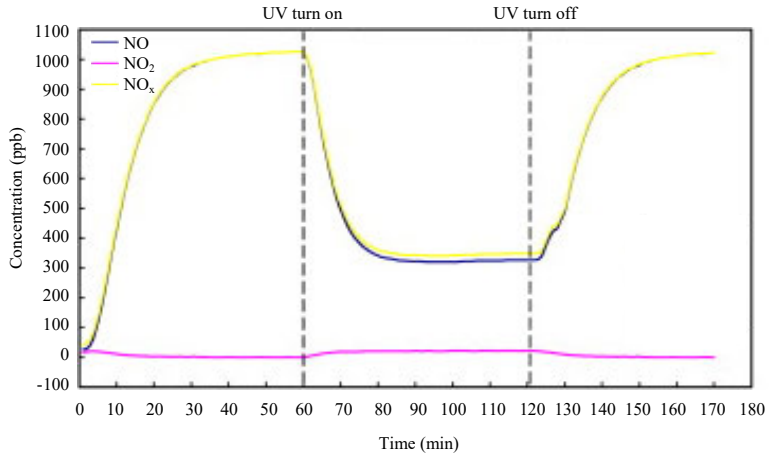

Fig. 3: Results of photocatalytic paving blocks' elimination of NOx in a laboratory[6]

photodegradation of NO. The ability to remove NO also rose along with the block's porosity. Hence it's crucial to consider the choice, size and composition of the aggregate material employed in the mix design.

As part of the aggregates in the blocks, crushed recycled glass cullet was also employed and it was discovered that this material's light-transmitting properties improved the blocks' ability to remove NO. In this work, three different varieties of TiO_2 were investigated and their effects on NO elimination were measured. Based on the outcomes of the experiment, the best mix design-which includes recycled glass, sand, cement and TiO_2-was chosen[5,7].

Experimental process

Preparation of materials: The cement utilized in this study is Ordinary Portland Cement (OPC), which is marketed in Malaysia. Coal-fired electricity generating produces furnace bottom ash (FBA), which is used. As coal is burned, the coarser material that settles to the bottom of the furnace is known as FBA[8].

To create the surface layer, just the fraction that made it through a 2.36 mm sieve will be used. In this investigation, recycled aggregate (RA) is also utilized. It is C and D garbage that has been crushed and is being recycled temporarily. Only the lesser fraction of the fine aggregate was used for this study's surface layer of the blocks after the C and D waste was mechanized sorted at the plant[9]. About 2.36 mm is the largest size of recycled fine aggregate that will be used.

Mix proportions: Mixes made with sand, water, TiO_2, RA and FBA. A number of mixes are being prepared to determine the effects of titanium dioxide and amounts on NO removal efficiency because this study focuses on the usefulness of recycled materials. It is possible to produce mixes with different cement to aggregate ratios, such as 1:2, 1:2.5 and 1:3. A significant portion of the mixes are created with aggregate sizes ranging from 300-2.36 mm. By creating samples with TiO_2 (P-25) content ranging from 0.06-0.08%, as indicated in Table 1, the varied amounts of TiO_2 were examined.

Table 1: This table displays mixtures made with various ingredients

	Proportions in relation (by weight)					
Ratio	Cement	RA	Sand	FBA	TiO_2	Water
R1:2	1	2	1.5	0.55	0.06	0.28
R1:2.5	1	2.5	1.5	0.65	0.07	0.30
R1:3	1	3	1.5	0.75	0.08	0.32

Equipment: A gas reactor serves as the major component of the experimental setup. The chamber reactor had the following dimensions: 700 mm in length, 400 mm in width and 130 mm in height. Figure 4 depicts the reactor cell's design. The reactor is constructed of materials that can tolerate highly irradiated UV-A light while not absorbing the applied pollutant. A tightly fitting glass plate made of borosilicate glass covered the reactor's top, allowing UV-A radiation to pass through with almost little resistance[10].

The reactor has an output and sampling inlet to allow gas to exit the reactor. The photo catalyst was activated using two 10 W UV-A fluorescent lamps (black lights), which emit primary UV light at 365 nm wavelengths. A UV meter (Spectroline DRC-100X) was used to measure the intensity, which was found to be 10 W m 2 at the center of the reactor, where the test samples were also placed. Outside the reactor, the light source was placed and its distance from the reactor was changed until the desired intensity was obtained[11].

RESULTS

Influence of local material on nitrogen oxides photo degradation: Figure 5's depiction of the NO photodegradation data shows that the RA mixes

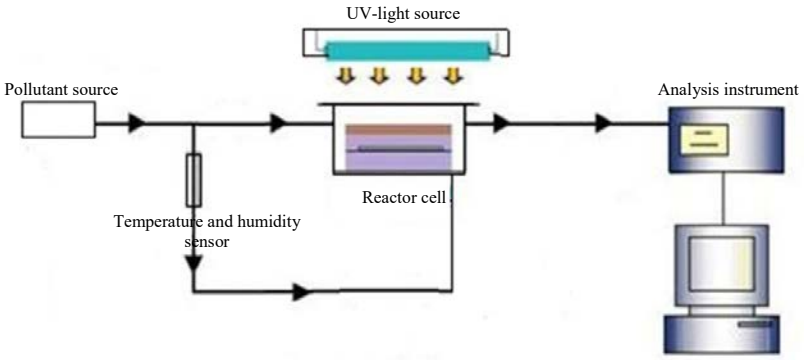

Fig. 4: Flowchart of the test configuration

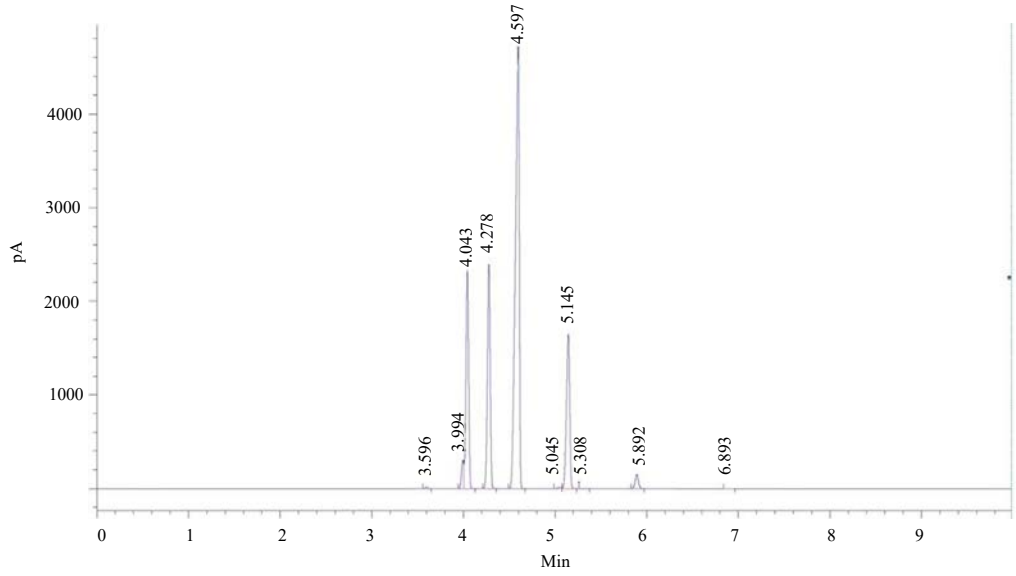

Fig. 5: A 90-day test comparing various mixtures to eliminate NO

removed substantially more NO than the sand mixes did. This is most likely caused by the fact that RA is more permeable than sand. The outcomes also show that when FBA was incorporated into the mix design, the NO removal somewhat increased. This may be because FBA particles have larger porosity, as seen by their relatively low specific density when compared to sand and RA particles[11,12].

Produce of cement/aggregate ratio on nitrogen oxides photo degradation: The results indicate that the NO removal increased as the cement concentration decreased for various cement to aggregate ratios. When the cement to aggregate ratio went from 1:2 to 1:3, specimens saw an increase in NO elimination of about 30%. Due to the tiny particle size of cement grains and the ease with which hydrated cement particles could fill the spaces within the specimens, the surface area available for pollutants was decreased, which led to an increase in NO removal as a result of the change in cement content. Although, lowering the cement concentration was advantageous for NO elimination, the surface layers' adopted cement content should also take into account the essential mechanical strength needed for paving applications. According to preliminary investigations, the materials for the surface layer should have a minimum cement to aggregate ratio of 1:3[12,13].

Aggregate particle size effects on the photodegradation of nitrogen oxides: As altering the particle size distribution of aggregates would inadvertently impact the porosity of the specimens depicted in Figure 6, it was thought that the specimens prepared with various aggregate sizes would affect their capacity to remove NO. The specimens were split

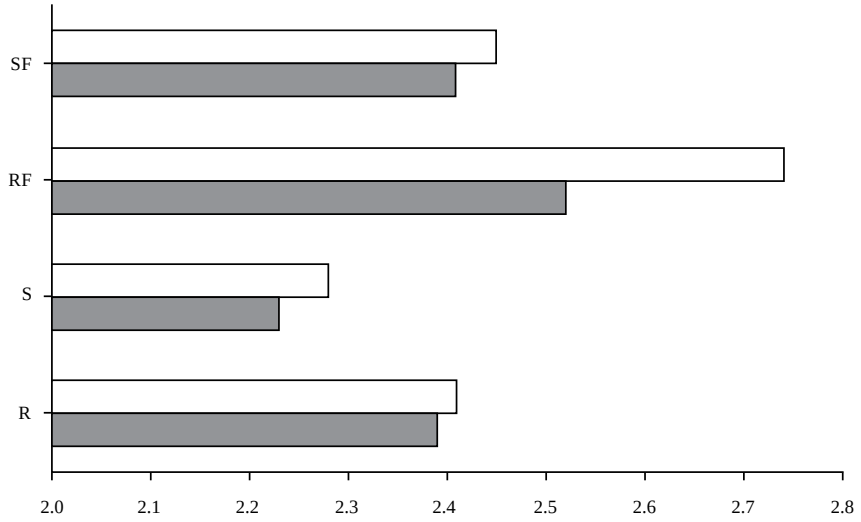

Fig. 6: NO specimens with varying aggregate sizes shall be removed

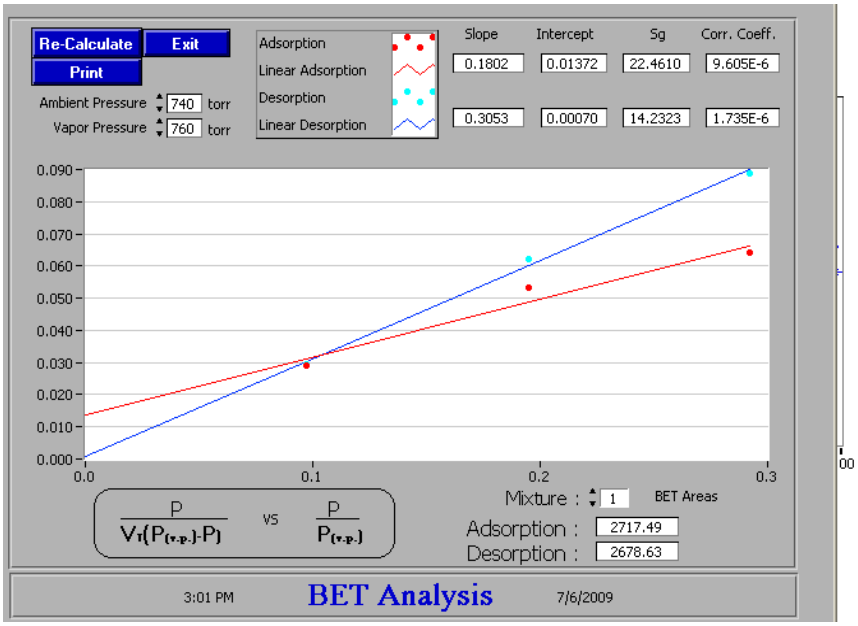

Fig. 7: Porosity and NO removal for specific mixtures are compared

into two groups; one contained all aggregate sizes below 2.36 mm, while the other only contained aggregate sizes between 300 m and 2.36 mm. The specimens evaluated at 90 days with a cement to aggregate ratio of 1:3 are shown in the second group[14]. The results show that the more porous specimens (those made with aggregate sizes between 300 m and 2.36 mm) had a roughly 4% greater NO removal rate[13,15].

The impact of porosity on the photodegradation of nitrogen oxides: All of the above-mentioned elements that could have an impact on NO elimination were connected to porosity. Figure 7 compares the measured porosity of some of the chosen blends with NO removal. It is evident that the rate of NO elimination increased as porosity rose.

Impact of porosity on the photodegradation of nitrogen oxides: All of the above-listed variables that could have an impact on NO_2 removal had to do with porosity. Figures 5 and 6 compare the measured porosity of several of the chosen mixes with NO2 removal after 4 and 5 weeks of the test, respectively. It is obvious that when porosity rose, the rate of NO_2 elimination increased as well. Xiao[14] demonstrates

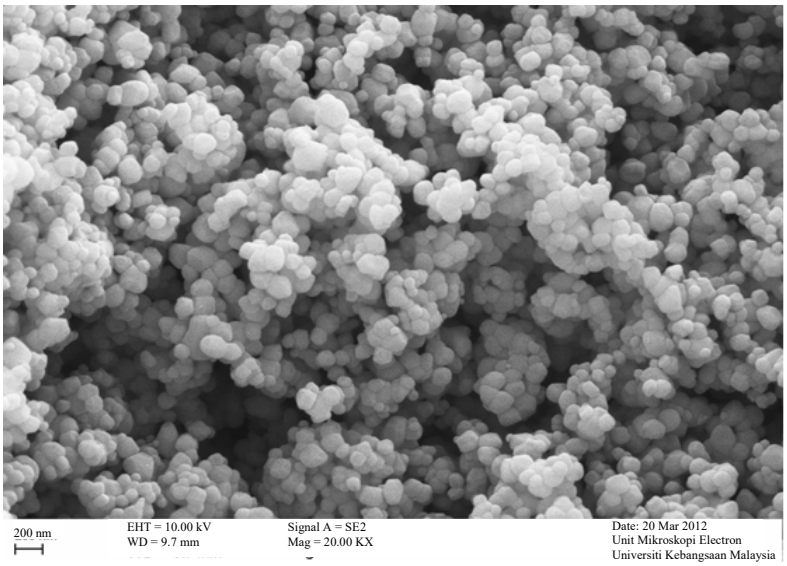

Fig. 8: SEM micrograph of the thin layer of titanium dioxide (TiO_2) following adsorption of target pollutants on the surfaces of concrete blocks, 200 nm scale, 20.000x magnification

that the type of material being utilized has a significant impact on the relative porosity's affect and that when high levels of relative humidity are used, the effect at the surface outweighs the oxidizing effect (Fig. 8).

CONCLUSION

This paper presents the results of an assessment of the variables influencing the prepared surface layer of the composite panel's capacity to eliminate NO via photocatalytic activities. The anticipated results show that the surface layer's porosity is significant, thereby increasing the area that is available to react with contaminants. The kind of materials used to produce them had an impact on how porous the surface layer was. The panels' porosity increased as a result of the use of less dense materials. The porosity of the blocks was impacted by the materials' particle size distributions as well. The porosity of the surface layers was increased by materials with fewer tiny particles. The ability to remove NO was clearly correlated with changes in the cement to aggregate ratio of the mixtures. NO removal was improved in mixes made with a lower cement to aggregate ratio. The ability to eliminate NO varied among specimens evaluated at various curing ages. According to the findings, photocatalytic activity declined with aging but stabilized after 90 days.

ACKNOWLEDGMENT

The authors wish to express their sincere thanks to prof. Mohd. Zain the sponsor of the research group and I offer my regards and blessings to all of those who supported me in any respect during my work.

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