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Photocatalysts, Degradation, Reaction and Analysis Photocalalysis Reactorfor Air Purification

Nader Beheshti, Seyed Javad Mohammadi Baygi and Sajjad Zangeneh
Islamic Azad University, Damghan Branch, Damghan, Iran

Abstract: Photocatalytic process for many years as one of the world's environment solutions used in industrialized countries. Nanotechnology is the creation of a new approach in the future photocatalyst huge industry in this area promises. Photocatalytic oxidation processes, pollution caused by ultraviolet radiation in the presence of catalysts such as titanium dioxide or zinc oxide semiconductor completely destroyed and converted to CO_2 and H_2O are. Photo nanostructured catalysts with high catalytic properties of hydrophilic and power due to their high surface to volume ratio is one of the key technologies in environmental pollution control requirements. The main objective of the project review and evaluate the photocatalytic degradation of pollutants in smoke from fossil fuels during the process of photocatalytic reactions in an air purification system. In this regard, the mechanism of action of the photocatalyst, types and characteristics and application of photocatalytic and the impact of the main operating parameters such as tiny fraction of the mass of pollutants such as CO_2, CO, C_3H_6, H_2O, NO_2, P, SO_2 and dynamic pressure under the photocatalytic reaction was studied. The results photocatalyst and mass fraction pollutants after considerable damage photocatalyst photocatalytic reaction compared to the reaction of pollutants before the show.

Key words: Photocatalytic degradation, environmental pollutants, radiation, semiconductor, CO_2

INTRODUCTION

With urban development and population growth, the spread of industries, the importance of controlling environmental pollution is every day more than ever. Several processes for the purification of water pollutants, waste water and air as well. One of the disadvantages of conventional treatment processes such as the chemical and physical contaminants and pollutants chemical separation, coagulation, flocculation, adsorption on activated carbon, reverse osmosis, filtration and so this method is that only the transfer of pollution from one sector to another, they are condensed and thus produce a new contaminants that need to more refined and In fact are non-destructive processes. In recent years, advanced oxidation processes as an alternative to conventional methods of treatment have been used. These methods are based on the production of highly reactive species such as hydroxyl radicals are capable of a wide range of organic contaminants to oxidize quickly.

Among the advanced oxidation processes, as a way of engaging and successful heterogeneous photocatalysts for the decomposition of organic pollutants are used (Daneshvar *et al*., 2004; Stylidi *et al*., 2003). Photocatalyst technology are widely discussed and studied since 1970. Many studies aimed at understanding the structural and fundamental processes and increase the efficiency of the photocatalyst, especially for the control of pollution of air, water and soil have been carried out.

Because of the increased attractiveness photocatalitical analysis of the feasibility of using atmospheric oxygen as oxidizer, the process of mining facilities completely under environmental conditions and organic matter into water, carbon dioxide and mineral acids (Akyol *et al*., 2004; Stylidi *et al*., 2003). The main advantages of this technology: photocatalyst as a substitute for conventional treatment systems with high energy consumption which can have the use of clean energy and renewable solar recommended. Unlike the conventional methods for filtering pollutants from one form to convert the boiler to the formation of photocatalytic products are harmless. This process can be used to decompose the hazardous substances contained in waste water types used. This process can be used to refine the liquid phase, gaseous and solid (soil) be used. photocatalytic reaction conditions balanced and relatively short reaction times and fewer chemicals are required. The process can be used to recycle metals and turning them into non-toxic or less toxic metal cases used.

The main applications for this technology have been studied include: removal and destruction of colors, reduced COD, mineralization dangerous organic

Corresponding Author: Nader Beheshti, Islamic Azad University, Damghan Branch, Damghan, Iran

compounds such as cyanides, heavy metals treatment, breakdown of fungicides, herbicides and insecticides harmful , water treatment and disinfection, destruction of unpleasant and foul-smelling substances, soil decontamination, purification and decontamination of indoor air and destroy cancer cells and virus (Kabra *et al*., 2004).

MATERIALS AND METHODS

The mechanism of action of photocatalyst: At the same time photocatalyst consisting of two techniques with different modes of operation. photocatalyst in which the energy provided by radiation.

Catalyzing effect on the reaction speed: Today, semiconductors are widely used for catalysts in heterogeneous photocatalytic processes Despite the continuous electron states are metals, semiconductors, an area devoid of energy. In other words, the energy band structure of semiconductors (Palmisano and Sclafani, 1997). The energy levels of atoms covalent bond between the valence band and the energy levels that are higher place called conduction band. Area of high agitation that filled valence band and the empty conduction band is spread below the band gap or gap power. Which determines the wavelength of the radiation sensitive semiconductor. More or equal to the absorption of radiation Energy Band Gap (EBG) is a semiconductor, the promotion of an electron from the Valence Band (VB) to the Conduction Band (CB) and holes in the valence band creates. After excitation of electrons and holes may be separated into several different paths to arrive (Fig. 1).

As a result of the migration of holes and electrons in the organic or inorganicsemiconductor electron transfer to adsorbed species occurs or solvents. The electron transfer from any organic or inorganic solvent adsorbed on the surface of the semiconductor can be formed. If the reactive species before they are absorbed on the surface, the electron transfer process will be more effective. Electrons in the semiconductor can be an electron species (A) to restore (Route C). Holes can also toward the surface, where the species is the movement of electrons and oxidize it (Route D). These electrons and holes can also be combined emission of heat energy or luminescence again that it can be inserted into the semiconductor particle (Route B) or on its surface (Route A) take place (Qu *et al*., 1998).

The types and characteristics photocalalysis: Semiconductors that are used as photocatalysts have special properties such as energy gap suitable, acceptable stability against light, are non-toxic and inexpensive.Various materials such as TiO_2, ZnO, CDs, MoS_2, Fe_2O_3, WO_3 and their compositions as photocatalyst. The decomposition of organic and inorganic pollutants have been studied (Table 1) (Kabra *et al*., 2004).

Table 1: Energy gap and the physical properties of semiconductors used in photocatalytic applications

Energy gap (ev)	Photocatalytic	Energy gap (ev)	Photocatalytic
3.02	TiO_2 (rutile)	1.1	Si
3.1	Fe_2O_3	1.2	Wse2
3.23	TiO_2 (anatase)	2.2	r-fe203
3.2	Zno	2.4	CDs
3.4	Srtio3	2.7	V205
3.5	SnO_2	2.8	Wo_3
3.7	Zns	3.0	Sic

In light photocatalyst corrosion resistant and should remain stable under a variety of reaction conditions. On the other hand, when you use them again, the response must optimum efficiency. Some of catalysts such as ZnO, CDs in reaction (reaction (1)) fall under the optic destruction.

Reaction 1: $ZnO+h \rightarrow Zn+O_2$. But, the number of catalysts such as TiO_2 and Wo_3 good stability in response indicate. Ray and Beenackers (1997) in their study on responses photocatalytic decomposition of phenol with TiO_2 and ZnO found that after the end of the reaction remains in the environment of the such as. The photocatalytic titanium dioxide Ti 4+Zn+2 in not available but the best deal on the stable performance and provides a catalyst in the aquatic environment and the most common and the most common substance that is used as a catalyst.Remove contaminated water containing toxic organic pollutants using TiO_2 and sunlight will account for a large part of the investigation (Legrini *et al*., 1993; Hoffmann *et al*., 1995).

Titanium dioxide is a polymeric material that is crystalline in three phases. Anatase, rutile and anatase type Brukit that it is very good photocatalytic character. Energy gap anatase 2/3 ev is located in the area of UV sunlight and UV light as the sun is just 3-4% should apply another light source to redox reactions on the surface of the catalyst to be done. Beenacckers and his colleagues used high pressure mercury lamp to produce UV-intensity and of 213 W m^{-2} andtitanium dioxide Degussa P25 and Hombikat UV100 type usedfor color removal and showed that increasing light intensity up to 500 W m^{-2} increased decomposition of colors. On the other hand, to optimize the amount of catalyst needed maximum efficiency in photocatalytic systems is essential.The optimum amount of catalyst used depends on the type and size and type of reactor is analyzed pollutants. For example, in many reactions if more than a certain amount of the TiO_2 photocatalytic reaction efficiency is reduced for two reasons: due to high concentrations of TiO_2 particles

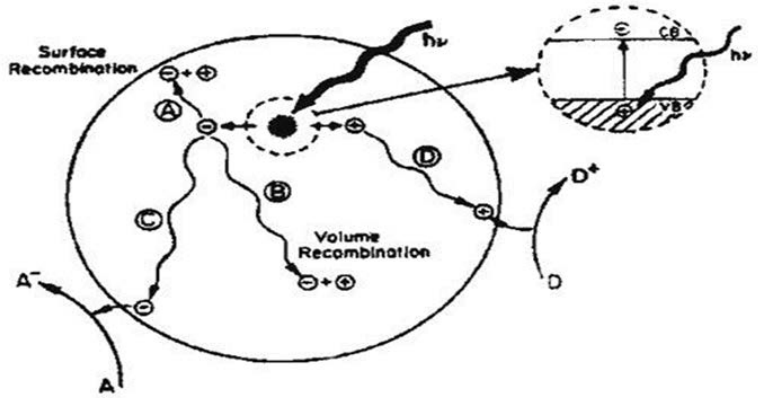

Fig. 1: photocatalytic reaction on the surface of the catalyst particle

agglomeration, the number of active sites in the catalyst surface is reduced. at the concentration of catalyst increases the amount of light scattering (Kabra *et al*., 2004).

As mentioned in nanometer-scale TiO_2 has a very high surface to volume ratio. So that in terms of features, excellent photocatalytic act.But there is a problem that nano-sized TiO_2 it is a large energy gap. In terms of chemical bonding and anti-bonding orbitals This is due to reduced bandgap. The resulting increase should therefore specific physical and chemical methods used to modify the electronic structure of the catalyst. A group of researchers to reduce the energy gap in nano-sized particles of different metals into the catalysts were doped (Anpo and Takeuchi, 2003; Amy *et al*., 1995). In general, we can say that their heterogeneous photocatalytic processes occur in 2 ways: as a suspensio consolidation of catalysts on the base material. Suspension systems compared to fixed systems are more effective catalyst surface due to the absence of mass transfer limitations and specific surface area of the particles is. The problem is that the catalyst system in the recycling and separation of the fine being economically costly. Another problem limiting the penetration depth of light by increasing the number of particles in suspension which this phenomenon occurs. This problem can be fixed by using a catalyst. To stabilize the catalyst base material of different materials can be used. The holder must be physically strong chemical bonds and create a catalyst.Stabilization of catalyst systems also have some weak points such mass transfer limitations, reducing the surface area and destroyed much of the radiation by the base material (through absorption and scattering) can be named. Of course, choosing a suitable base for catalysts can reduce weaknesses (Matthews, 1992).

RESULTS AND DISCUSSION

Application photocalalysis: Generally can be photocatalysts for the oxidation of organic compounds and inorganic compounds used revival. Redox behavior when in contact with TiO_2 indicate oxidation compounds or optical restoration materials (Kabra *et al*., 2004). This process has a variety of applications, particularly in water and air. Water and air purification and disinfection equipment for hospitals and medical or environments where growth and proliferation of plants and animals are susceptible to infection, kill germs and organisms in the water, air or surface is required. Air pollution is a serious problem worldwide. About ninety percent of the hourly people to live outdoors and are exposed to pollutants such as carbon monoxide, formaldehyde, volatile organic compounds from exhaust gases of vehicles and industrial centers are located. One of the most important advances in photocatalysis applications use them as purifying the air.

Therefore, the use of smart coatings, metal oxide semiconductor photocatalysts such as WO_3, CdS, TiO_2 and ZnO are useful in the treatment environment. Among them the use of titanium dioxide due to high chemical stability, low toxicity and low cost is more common. Use the filters with honeycomb-shaped cells or porous substrates, UV radiation in the interior allow them to influence their performance higher.

Performance nano particles of titanium dioxide in the guise of purifying the air: Electrons and holes as a result of photocatalytic reaction on the surface of titanium dioxide nanoparticles can form water andoxygen ions in the environment, superoxide and hydroxyl free radical turn. Also cratering, organic pollutants into water and carbon dioxide and other organic materials are converted by the safe. Because titanium dioxide photocatalytic

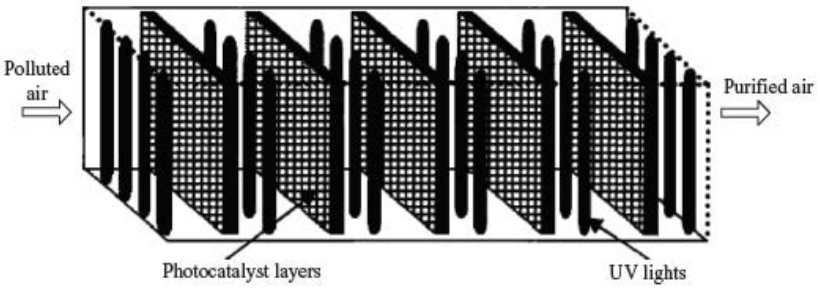

Fig. 2: The internal structure was analyzed photocatalytic reactor pages

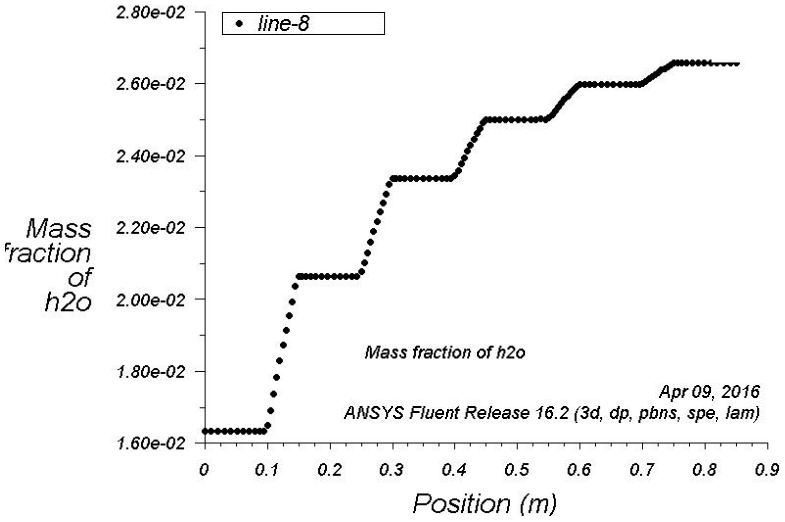

Fig. 3: Mass fraction of hydrogen-dioxide in different situations wrapping photocatalytic filter

reaction is a surface chemical reaction by reducing the particle size, surface area to react with organic pollution and other pollution increased and thus better optical damage done. On the other hand, according to the laws of light and optics, the smaller particles are more attracted to shorter wavelengths. So, nano particles of titanium dioxide UV energy has attracted more than normal particle size, the optical efficiency will be greatly increased.

Analysis and response photocatalytic reactor for air purification with the helpofansys software: Today, from photocatalysts in different industries to control and eliminate gaseous pollutants are used. Here to analyze and demonstrate ANSYS FLUENT Software was used photocatalytic reaction, so that the boundary conditions and material pages to mobile photocatalytic reaction was considered as:

- Photocatalytic filter dimensions: 25×25 cm and a thickness of 5 cm
- The number of photocatalytic filter: 5
- Input speed air pollutants: 25 m sec^{-1}

Photocatalytic filter material: titanium dioxide (anatase) Many studies show that the photocatalytic activity of anatase to rutile is more nest. Anatase titanium dioxide energy gap is equal to 3/2 ev.

The energy of a photon with a wavelength of 388 nm equivalent amount of energy. In other words, if a photon with a wavelength of less than this amount causes excitation of electrons from the valence band to hit the titania conduction band and holes in the surface of the trapped electron pair. Holes are strong oxidizing power. One of the acceptor molecule that participates in the reduction reaction of oxygen air. The reaction is carried out as follows shown in Fig. 2 and 3.

$$CO + 1/2O_2 \rightarrow CO_2$$

$$C_3H_6 + 9/2O_2 \rightarrow 3CO_2 + 3H_2O$$

$$NO_2 + 2CO_2 \rightarrow 1/2N_2 + 2CO_2$$

$$SO_2 + 2CO \rightarrow S(s) + 2CO_2$$

$$\text{Particle} \rightarrow \text{Particle}(s)$$

After photocatalytic reaction results were shown by the softwareare as follows shown Fig. 4-9.

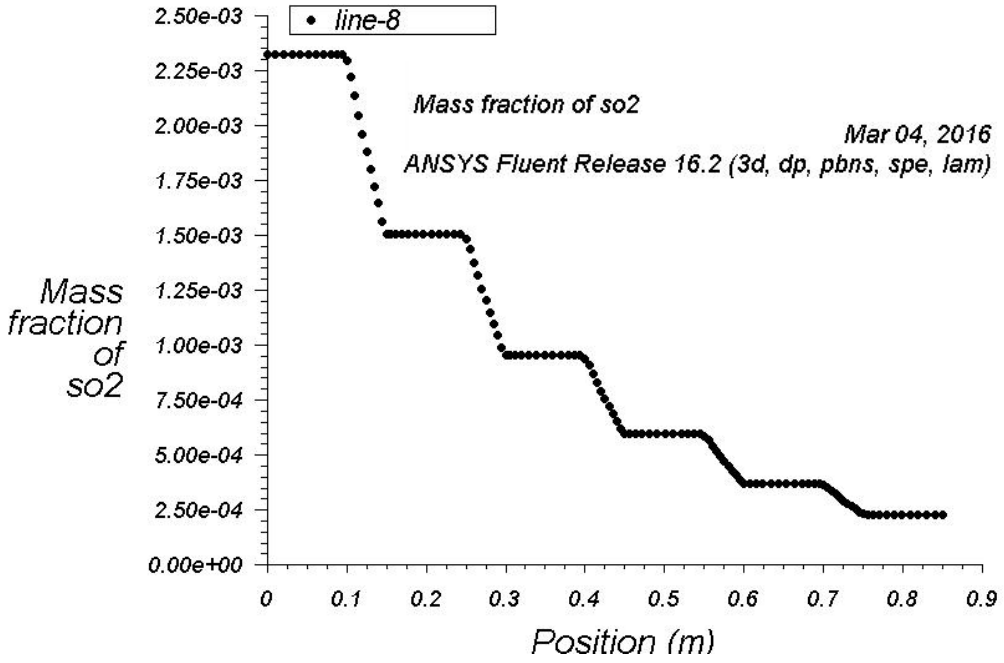

Fig. 4: Mass fraction of sulfur dioxide in different situations wrapping photocatalytic filter

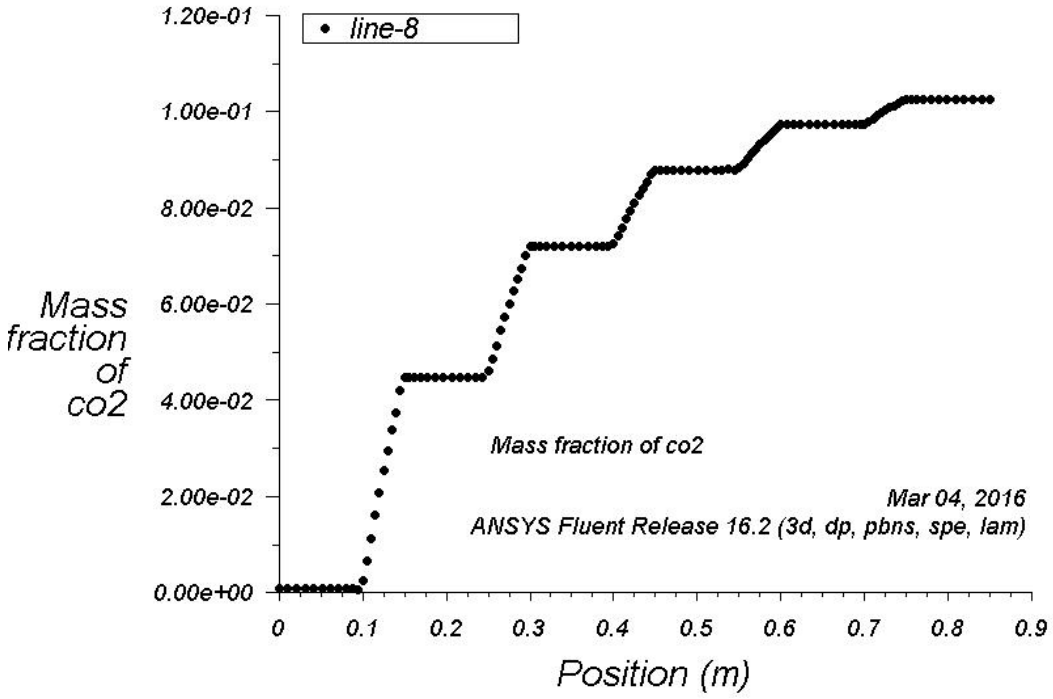

Fig. 5: Mass fraction of carbon dioxide in different situations wrapping photocatalytic filter

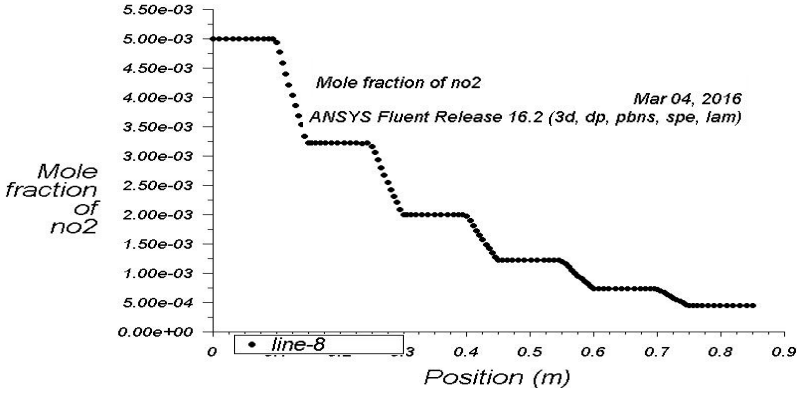

Fig. 6: Mass fraction of nitrogen dioxide in different situations wrapping photocatalytic filter

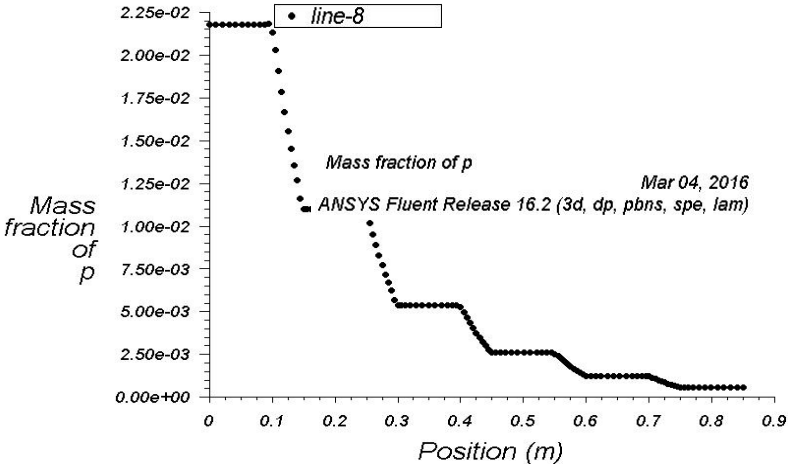

Fig. 7: Mass fraction of particles in different situations wrapping photocatalytic filter

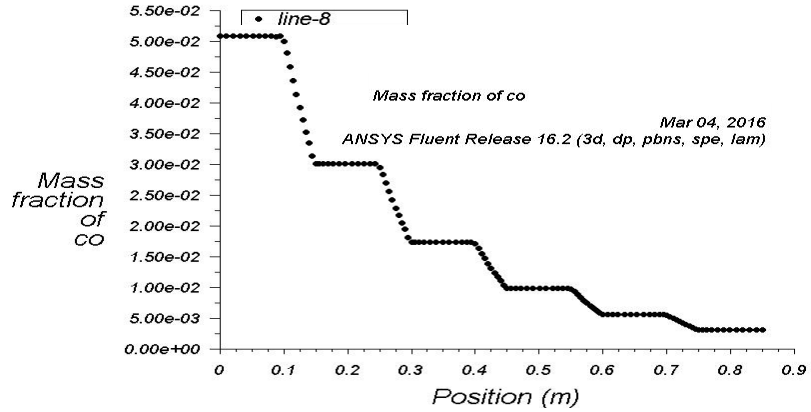

Fig. 8: Mass fraction of carbon monoxide in different situations wrapping photocatalytic filter

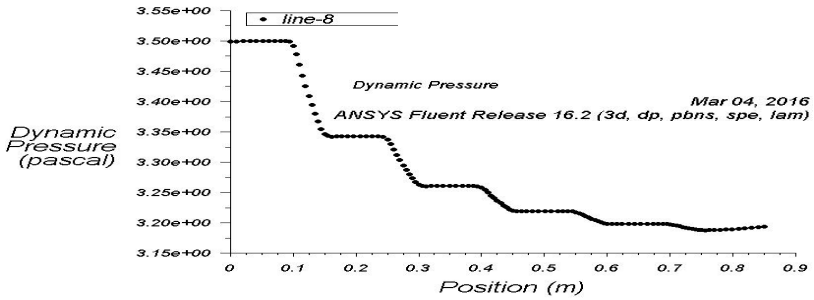

Fig. 9: Dynamic pressure diagram during a photocatalytic purifier

CONCLUSION

In general, photocatalysts and catalysts that are activated in the presence of light and the means by which a dangerous gases such as Carbon monoxide (CO), resulting from the incomplete combustion of Hydrocarbons (HC) and Nitrogen Oxide (NOX) and into nontoxic gases, water vapor, nitrogen and carbon dioxide are. The results show that the volume or concentration of hazardous gases such as Carbon Monoxide, unburned hydrocarbons (C_3H_6) and Nitrogen dioxide (NO_2) and Sulfur dioxide (SO_2) is reduced with the passage of each filter non-toxic gases such as water vapor and D. carbon dioxide and nitrogen increases.

REFERENCES

Akyol, A.H., C. Yatmaz and M. Bayramoblu, 2004. Photocatalytic decolorization of Remazol Red RR in aqueous ZnO suspensions. Applied Catal. B Environ., 54: 19-24.

Amy, L.L., L. Guangquan and J.T. Yates, 1995. Photocatalysis on TiOn surfaces: Principles, mechanisms and selected results. Chem. Rev., 95: 735-758.

Anpo, M. and M. Takeuchi, 2003. The design and development of highly reactive titanium oxide photocatalysts operating under visible light irradiation. J. Catal., 216: 505-516.

Daneshvar, N., D. Salari and A.R. Khataee, 2004. Photocatalytic degradation of azo dye acid red 14 in water on ZnO as an alternative catalyst to TiO_2. J. Photochem. Photobiol. A. Chem., 162: 317-322.

Hoffmann, M.R., S.T. Martin, W. Choi and D.W. Bahnemann, 1995. Environmental applications of semiconductor photocatalysis. Chem. Rev., 95: 69-96.

Kabra, K., R. Chaudhary and R.L. Sawhney, 2004. Treatment of hazardous organic and inorganic compounds through aqueous-phase photocatalysis: A review. Ind. Eng. Chem. Res., 43: 7683-7696.

Legrini, O., E. Oliveros and A.M. Braun, 1993. Photochemical processes for water treatment. Chem. Rev., 93: 671-698.

Matthews, R.W., 1992. Photocatalytic oxidation of organic contaminants in water: An aid to environmental preservation. Pure Appl. Chem., 64: 1285-1290.

Palmisano, L. and A. Sclafani, 1997. Hrterogeneous Photocatalysis. Wiely, New York, USA.

Qu, P., J. Zhao, L. Zang, T. Shen and H. Hidaka, 1998. Enhancement of the photoinduced electron transfer from cationic dyes to colloidal TiO_2 particles by addition of an anionic surfactant in acidic media. Colloids Surf. A. Physicochem. Eng. Aspects, 138: 39-50.

Ray, A.K. and A.A. Beenackers, 1997. Novel swirl-flow reactor for kinetic studies of semiconductor photocatalysis. AIChE. J., 43: 2571-2578.

Stylidi, M., D.I. Kondarides and X.E. Verykios, 2003. Pathways of solar light-induced photocatalytic degradation of azo dyes in aqueous TiO 2 suspensions. Appl. Catalysis B. Environ., 40: 271-286.