Titaneon: the eco smart lamp to degrade cigarette smoke pollutants

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Abstract. The purpose of this study is to find out the results of the "TITANEON" degradation power test on hazardous CO (carbon monoxide) compounds qualitatively and quantitatively and to explain the working system of the lamp. The research methods used in this study are (a) preparation: tools and materials, design testing tools; (b) conducting research: TiO2/Co synthesis, coating, tool performance test and data processing and analysis; (c) evaluation. The test results in this study were divided into two, namely qualitative and quantitative. In the qualitative test results, the "TITANEON" lamp is able to degrade CO compounds for 20 minutes. The quantitative results from 0 minutes amounted to 15526.24 ppm, 5 minutes later the CO concentration was 6202.82, in the next 15 minutes CO concentration was 2549.98 ppm and in the last 20 minutes the CO concentration was 1871.89 ppm. The system works, namely the first light that involves TiO2 nanoparticles will excite electrons from the valence band to the conduction band while producing positive holes in the valence band and negatively charged electron pairs. After that, TiO2 nanoparticles are transformed into super oxide compounds which release active oxygen species (O2 radicals and OH radicals), these compounds will degrade cigarette smoke compounds into CO2 and H2O compounds through photocatalytic mechanisms.

1. Introduction
The problem of environmental pollution is a serious problem that is currently faced by people around the world. Until now there are still not many countries that can solve this problem optimally. Various types of pollutants are very potential causes of environmental pollution and can also harm human health. One type is air pollution. Air quality is greatly influenced by the size and type of pollutant sources that exist, such as human activities. Cigarette smoke is one of the air pollutants derived from human activities that is very dangerous for both active smokers and passive smokers [1]. Cigarette
smoke is a complex mixture consisting of more than 100 carcinogens [2, 3]. In Southeast Asia, Indonesia was the first rank with 39.5% smokers over the age of 15 [4].

There are many chemical compositions contained in one cigarette. This compound can include more than 4000 types of harmful compounds [5]. Meanwhile, the pollutant from cigarette smoke that has the potential to be dangerous is CO (Carbon Monoxide) gas content. This is a gas that can reduce the ability of blood to carry oxygen. Smokers of more than 20 cigarettes a day have carbon monoxide in their blood (COHb) ten times greater than non-smokers [6]. Carbon Monoxide here, formed when the combustion of cigarette lasting in long period.

Various efforts have been made by the government to decrease the number of smokers in Indonesia ranging from making anti-smoking advertisements to raising cigarette taxes for smoking in public areas, but these efforts are ineffective in decreasing the number of smokers in Indonesia. cigarette smoke that is very dangerous for the environment because cigarette smoke is a toxic substance and can cause disruption to human health, cancer and even death.

In addition, nanotechnology in the world is currently developing rapidly. One example is nano titanium dioxide (TiO2). The superiority Tantium dioxide (TiO) is not disputed, is inert, has good photocatalyst properties, low cost, dissolved, insoluble in water, used in semiconductors with wide band gap, has a large surface area, good optical properties and is environmentally friendly [7-15].

TiO2 is a good semiconductor [7, 8] and semiconductors are the most widely used as photocatalysts in the application of photocatalytic reactions because of their superiority over other types of semiconductors [16]. The working principle of TiO2 photocatalysts is that when nano sized TiO2 is exposed to UV light it forms super oxide compounds which can degrade various organic compounds [17]. One of the compounds that can be degraded is cigarette smoke. So that when the TiO2 is coated on other substances such as glass, the TiO2 can degrade cigarette smoke in the surrounding environment when it is initiated with UV light.

The use of TiO2 as a photocatalyst has the disadvantage of being less effective if applied in the environment. TiO2 is only active under UV radiation because the TiO2 band gap energy is relatively wide. This is an obstacle in the use of sunlight based on TiO2 because the UV rays that enters the earth only range from 4-5% while 45% is visible light. One solution to this problem is coating TiO2 with Cobalt (Co) [18]. Coating TiO2 with Cobalt (Co) will increase catalytic photo activity and shift uptake towards visible light [18]. With these modifications, TiO2 works as a photocatalyst to degrade organic compounds such as smoke pollutants will be more effective.

2. Methods
The method used in this study is an experiment, beginning with the synthesis of TiO2 nanoparticles done through the sol gel method. The addition of cobalt nitrate aims to increase the composition of organic compounds to a wavelength of 550 nm [19] as in Figure 1.
After producing TiO2 / Co sol, the next process is TiO2 / Co sol coating on the lamp using a spray coating method. The first process is to clean the Philips 7-watt lamp using ethanol and acetone with the aim that when in the coating process, the layer is not easily separated. Second, spray using spray coating method, which is done by spraying TiO2 / Co soles on the surface of the lamp evenly using the air brush at room temperature and continuing with the heating process at 150°C for 30 minutes using the furnace. The result is that the surface on the lamp that has been coated with TiO2 / Co sol, which is initially white, will change to dark purple as in Figure 2.

![Figure 2. Spray Coating Process](image)

The purpose of testing the CO degradation in cigarette smoke is to determine the CO content in cigarette smoke and determine the degradation power of Titaneon against CO (carbon monoxide) hazardous compounds. This test was carried out in an integrated laboratory at Diponegoro University using a gas analyzer.

In the testing process, the first thing to do is to make a bulb tester equipped with a glass beam above it with a smoke pump hole and hole to put the cigarette beside the base. After the bulb tester is finished, the next step is to install the Titaneon lamp and cigarette into the bulb tester, then the cigarette is turned on and pumped until the smoke entering the bulb tester room is full. After the room is full, turn on the Titaneon lamp for up to 20 minutes. in the 0th minute, 5th minute, 15th minute and 20th minute the sample was taken to analyze CO content in cigarette smoke using a gas analyzer.

3. Results and discussion

A catalyst is a substance that can accelerate chemical reactions without the substance reacting, and the catalyst will form again in the final stage. A catalyst is a compound that can increase the reaction rate but is not consumed by the reaction. Catalysts are widely used in nature, laboratories and industry [20].

TiO2 semiconductors are widely used as photocatalysts, because they are inert, not toxic, and inexpensive [8, 9, 10, 11, 13]. In the photocatalytic process, when TiO2 semiconductors absorb UV light, the energy is equal to or greater than the energy gap (3-3.2 eV). The photon energy will used by electrons to move from the valence band to conduction [21]. Electrons that have been in conduction will be free to move, including the surface of particles and move to electron capture species around the particles. Positive holes formed in interact with water or OH ions - producing OH radicals. Catalysts used in this process have the ability to absorb photon energy [22].

The effectiveness of the Titaneon lamp in working as a cigarette smoke pollutant degradation unit is done by testing its performance in degrading the content of harmful CO (carbon monoxide) compounds in cigarette smoke. In this study, testing the effectiveness of these lights in degrading cigarette smoke was carried out qualitatively and quantitatively. The results of testing the performance of Titaneon lamps qualitatively in degrading cigarette smoke as in Figure 3.
Figure 3 shows that the degradation of dangerous CO (carbon monoxide) compounds by the Titaneon lamp occurs for 20 minutes. In the first 0 minutes the bulb tester is filled with cigarette smoke until it is thick from half a cigarette. Furthermore, at 1 minute the lights are turned on. As can be seen in the picture, the smoke degradation is very fast, as well as the minutes later. Until the last minute, which is the 20th minute, cigarette smoke is nowhere to be seen. This is indicated by the cigarettes, lights and the space inside has begun to appear. Meanwhile, the quantitative Titaneon lamp performance testing data which used a gas analyzer to degrade the hazardous CO (carbon monoxide) compounds in cigarette smoke as presented in Figure 4.

Figure 4 shows a comparison between the glass beams with ordinary lights to the glass beams in which there are Titaneon lamps to degrade the dangerous CO (carbon monoxide) compounds analysed using a gas analyser. These results indicate that CO concentrations in glass beams mounted by ordinary lamps are very slow to process CO degradation, while those on glass beams that are installed
with the Titaneon undergo a very rapid degradation process. Even at minute 20 the CO content remaining in glass beams with Titaneon is only 1871.89 ppm, decreased from 13654.35 ppm. This shows that Titaneon lamps are effective in degrading cigarette smoke CO pollutants. In general, there is a decrease in the results of CO concentration degradation as shown in Figure 5.

![Graph of Decreasing CO Concentration](image)

**Figure 5** Graph of Decreasing CO Concentration

The working system Titaneon in the degradation of CO (carbon monoxide) in cigarette smoke uses the TiO$_2$ photocatalyst process doped with Co (Cobalt). The process begins with an excitation photo, which is the light that affects TiO$_2$ nanoparticles which excites electrons from the valence band to the conduction band while producing holes in the valence band. The energy produced from these excited electrons causes electrons to be in the conduction band and produce negatively charged electron pairs and positive holes. After that, TiO$_2$ nanoparticles turn into super oxide compounds that release oxygen active species (O$_2$ radicals and OH radicals). These compounds will degrade cigarette smoke compounds into CO$_2$ and H$_2$O compounds through photocatalytic mechanisms. The photocatalytic process of TiO$_2$, when the TiO$_2$ semiconductor absorbs UV light, which has energy equal to or greater than the energy gap (3-3.2 eV). The photon energy will be used by electrons to move from the valence band to the conduction band [21]. The work system is presented in Figure 6.

![Titaneon Lamp Working System](image)

**Figure 6.** Titaneon Lamp Working System

The use of TiO$_2$ as a photo catalyst has the disadvantage of being less effective if applied in the environment. TiO$_2$ is only active under UV radiation because the TiO$_2$ band gap energy is relatively
wide. This is an obstacle in the use of sunlight based on TiO2 because the UV rays that enter the earth only range from 4-5% while 45% is visible light. One solution to this problem is coating TiO2 with Cobalt (Co) [18]. Coating TiO2 with Cobalt (Co) will be able to increase catalytic photo activity and shift uptake towards visible light [19]. With these modifications, TiO2 activity as a photocatalyst to degrade organic compounds such as smoke pollutants will be more effective.

4. Conclusion
The Titaneon Smart Lamp which degrades environmentally unfriendly cigarette smoke designed as an effort to degrade CO pollutants produced by cigarette smoke is quite effective in degrading CO compounds for 20 minutes. The test results in this study were divided into two, namely qualitative and quantitative. For the results of qualitative testing, the Titaneon lamp is able to degrade CO compounds for 20 minutes, while quantitatively it can be concluded that the CO concentration decreases.

The working system of the Titaneon lamp, which is the first light on TiO2 nanoparticles, will excite electrons from the valence band to the conduction band while producing positive holes in the valence band and negatively charged electron pairs. After that, TiO2 nanoparticles turn into super oxide compounds that release oxygen active species (O2 radicals and OH radicals), these compounds will degrade cigarette smoke compounds into CO2 and H2O compounds through photocatalytic mechanisms.

Further research and testing is needed to help develop this research, such as characterization testing and full support from relevant parties such as government, schools, and scientific institutions.

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