

**OPTIMALISASI AKTIVITAS FOTOKATALITIK TiO_2 TERDOPING
NITROGEN MELALUI VARIASI ZAT PEMBENTUK PORI UNTUK
APLIKASI REDUKSI ION Cd(II)**

SKRIPSI SARJANA KIMIA

Oleh:

SHAFINNA HANA FADHIA

NIM: 2110412028



Dosen Pembimbing I : Dr. Diana Vanda Wellia, M.Si

Dosen Pembimbing II : Prof. Dr. Syukri Arief, M.Eng

PROGRAM SARJANA

DEPARTEMEN KIMIA

FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM

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ABSTRACT

Optimization of The Photocatalytic Activity in Nitrogen-Doped TiO₂ through Variation of Pore-Forming Agents for Cd(II) Ion Reduction Application

by:

Shafinna Hana Fadhia (NIM :2110412028)
Dr. Diana Vanda Wellia*, dan Prof. Dr. Syukri Arief*
*Supervisor

The rapid expansion of industrial activities has led to an increased risk of heavy metal contamination, particularly cadmium (Cd), in aquatic ecosystems. Cadmium accumulation in the human body can cause severe organ damage and may ultimately result in death. Therefore, an effective technology is needed to mitigate the toxicity of cadmium. This study aims to explore the role of photocatalysts in reducing Cd²⁺ ions to elemental Cd using nitrogen-doped titanium dioxide nanoparticles (N-doped TiO₂) under visible light irradiation. N-doped TiO₂ was synthesized via a hydrothermal method using formamide as the nitrogen source. To investigate the effect of surface area on photocatalytic activity, various pore-forming agents (porogens) were introduced during synthesis. The variations of pore-forming agents used consist of two types, namely the polymer substances *polyethylene glycol* (PEG) and *polyvinyl alcohol* (PVA), as well as the non-polymer substance *cetyltrimethylammonium bromide* (CTAB), with the sample codes NTO-PEG, NTO-PVA, and NTO-CTAB, respectively. Undoped TiO₂ (TO) was used as a control. Successful synthesis was confirmed by X-ray Diffraction (XRD) analysis, which showed that all samples exhibited the anatase phase. The addition of nitrogen doping causes a shift and broadening of the diffraction peak at $2\theta = 25.3^\circ$ which is indexed on the (101) plane. Fourier Transform Infrared (FTIR) spectroscopy revealed absorption bands in the range of 1634–641 cm⁻¹, attributed to H–O–H bending or N–H bending vibrations in nitrogen-doped samples. BET full isotherm data demonstrated that the addition of porogens significantly increased the specific surface area compared to samples without porogens. Thermogravimetric Analysis–Differential Thermal Analysis (TGA–DTA) showed that the NTO–CTAB sample exhibited the highest thermal stability. UV–Vis Diffuse Reflectance Spectroscopy (UV–Vis DRS) indicated that nitrogen doping enhanced light absorption in the visible spectrum ($\lambda = 400–800$ nm) and reduced the energy gap compared to undoped TiO₂. Photocatalytic activity tests revealed that NTO–CTAB exhibited the most optimal performance, achieving a degradation efficiency of 96.1%. These findings confirm that structural modification of TiO₂ through nitrogen doping and porogen addition—particularly CTAB—synergistically enhances its stability, optical properties, and photocatalytic activity. Thus, this material holds promise as an environmentally friendly technology for remediating heavy metal-contaminated wastewater.

Keywords: Cd²⁺ Reduction, N-doped TiO₂, polyethylene glycol (PEG), polyvinyl alcohol (PVA), cetyltrimethylammonium bromide (CTAB).