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Antimicrobial, antioxidant and cytotoxic effect of Molybdenum trioxide nanoparticles and application of this for degradation of ketamine under different light illumination

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ABSTRACT

A hydrothermal method was employed to synthesize Molybdenum trioxide (MoO_3) nanoparticles. The synthesized samples were evaluated for photocatalytic properties and biological application. The nanoparticles characterized by scanning electron microscopy, powder X-ray diffraction, transmission electron microscopy, an energy dispersive X-ray spectrometer and UV–Vis DRS spectra. The synthesized MoO_3 NPs were found to be spherical in shape with size in the range of 75 nm. The synthesized MoO_3 nanoparticles have good optical properties with 2.78 eV of band-gap. The photocatalytic properties of the synthesized MoO_3 nanoparticles were carried out by performing the degradation of ketamine under visible, UV and sunlight irradiations. A high efficiency was observed between sunlight and MoO_3 nanoparticles for the photocatalysis reaction. Two compounds as intermediates of photo-degradation of ketamine under visible and UV lights were detected. The antifungal activity of the nanoscale MoO_3 against *Candida albicans* and *Aspergillus niger* was assessed using the disc-diffusion susceptibility tests. All MoO_3 nanoparticles concentrations showed good ABT radical scavenging activity. Then, this research has been presented to exhibit the synthesized MoO_3 NPs which indicated a high antibacterial activity against Gram negative and positive bacteria and were also proved to exhibit excellent cytotoxic influence on lung and breast cancer cell lines. The results show that the high applicability of MoO_3 nanoparticles biologically was great and is environmentally friendly.

1. Introduction

The presence of pharmaceutical ingredients in aqueous environment has raised increasing concerns in recent years. Typical sources of them are animal excrements, hospital waste, and sewage effluents. These compound concentrations are much lower compared with other conventional organic pollutants, a wide range of investigations reported that these drugs have raised concerns due to their potential impact on human and environment [1,2].

From 2008, many developed countries began examining controlled drugs in surface waters and wastewater urban. The methamphetamine and ketamine were found in wastewater treatment plants at 296 and 147 ng/L [3].

Ketamine is a synthetic compound used as an anesthetic and analgesic drug and also (illicitly) as a hallucinogen. This is a noncompetitive *N*-methyl-D-aspartate (NMDA) receptor antagonist introduced recently for analgesia in patients with chronic pain. The role of the NMDA receptor in processing nociceptive input and its ability to improve pain management and reduce opioid-related adverse effects have led to renewed clinical interest in ketamine [3].

Photocatalytic degradation of drug pollutants can be an effective alternative to biological methods for removal of drug contaminants. At present, UV disinfection is widely deployed in wastewater urban. Among many materials, semiconductors have shown as promise a photocatalyst because of its high chemical stability and photocatalytic reactivity [4–11].

MoO_3 is a large band gap semiconductor (2.90 eV) and, when crystallized, forms hexagonal or rectangular plates, depending on synthesis conditions [12]. Thermodynamically, the stability of the amorphous phases was lower than of orthorhombic MoO_3 [13]. This oxide is normally found in the orthorhombic phase, which is the main aim of much research due to its many applications [14–18]. This phase can be described as a layered structure formed by covalent double layers of MoO_6 octahedral [13,19–21].

The present study investigated to develop a photocatalytic active particle under different light; hence natural resource could be made use for the degradation pollutant bearing effluents.

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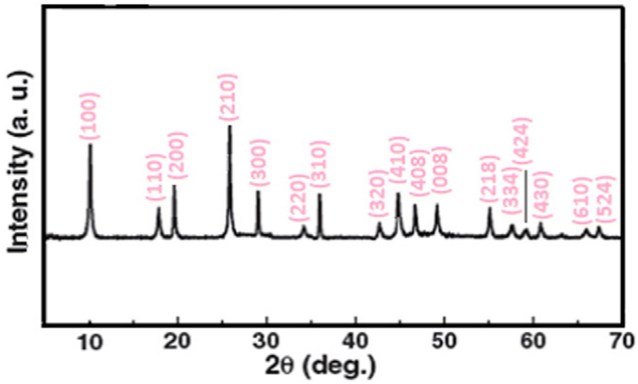

Fig. 1. X-ray diffraction analysis of MoO_3 NPs.

2. Materials and Methods

2.1. Materials

All the chemicals were obtained from Sigma-Aldrich Ltd., USA. All the chemicals used for the study were of analytical grade.

2.2. Preparation of MoO_3 NPs

The powders of 10 mL 0.2 M of ammonium heptamolybdate tetrahydrate were weighed into a Teflon-lined stainless steel autoclave of 50 mL capacity, and then 5 mL of 1.5 M HNO_3 aqueous solution was added in with stirring (the stirring was kept for a while until a homogeneous solution was formed). The autoclaves containing the reaction solutions were sealed and maintained at 150 °C for 12 h, then cooled naturally to room temperature. The as-formed precipitates were filtered, washed with distilled water and ethanol, and finally dried in a vacuum at 100 °C for 3 h.

2.3. Characterization Instruments

An X-ray diffractometer (XRD) Philips X'Pert, transmission electron microscopy (TEM, JEM-2100F HR, 200 kV), a scanning electron microscope (SEM), and a JEOL JSM-5600 Digital Scanning Electron Microscopewere used to characterize the nanopowders. UV–Vis DRS mensuration was performed in a double beam spectrophotometer (JASCO V-550). The catalyst compositions were analyzed with an energy dispersive X-ray spectrometer (EDX-700HS, SHIMADZU).

2.4. Evaluation of Photocatalytic Property

In the present research, degradation of ketamine as a pollutant by MoO_3 NPs was investigated using visible, UV and sunlight photocatalysis. The photocatalytic degradation was tested by photocatalysts and an aqueous solution of ketamine in an open cylindrical stainless glass vessel with a volume of 200 mL. In each experiment, 20 mg photocatalyst was suspended in 30 mL model ketamine aqueous solution with a concentration of 10 mg/L. Then, the suspended solution was placed in the dark for 30 min under magnetic stirring to check the adsorption–desorption capability. The concentration of ketamine after reaction was recorded as C_t and then experiments were carried out further for 60 min under visible (1000 W halogen) and UV lights (125 W UV lamp at 365 nm) light illumination. A second photoreactor for the solar photocatalysis experiments was constructed using a borosilicate

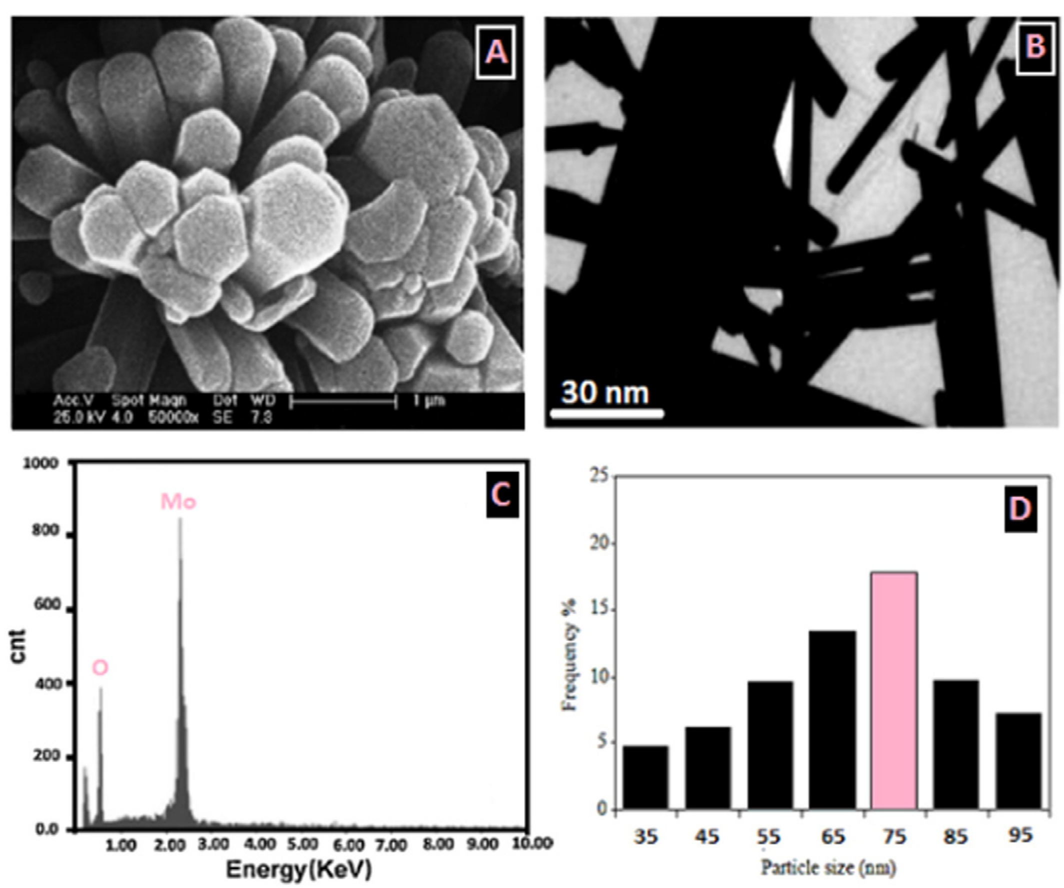

Fig. 2. SEM image (A), TEM image (B), EDX pattern (C), particle size distribution (D) of MoO_3 NPs.