学 位 論 文 審 査 の 要 旨

環境起学専攻　博士（環境科学）　氏 名　王 延 青

審査委員　主査　教 授　古 月 文 志
副査　教 授　田 中 俊 逸
副査　特任教授　荒 井 眞 一
副査　准教授　豊 田 和 弘
副査　准教授　神 谷 裕 一

学 位 論 文 題 名

Development of high-performance photocatalysts by using graphene and AgCl and/or AgBr nanoparticles as the constitutive elements for the decomposition of chemical pollutants

（グラフェンと塩化銀または臭化銀ナノ粒子を素材として用いた環境浄化用高性能光触媒の開発）

In this study, the candidate had created a new type of photocatalysts by using graphene and AgX (X = Cl, Br) nanoparticles as the constitutive elements for decomposition of chemical pollutants in water. Graphene is the thinnest sheet-shaped, carbon based nanomaterial with an ultra-large surface area and superior mechanical and electronic properties. Graphene, in this study, is found to be capable of facilitating the production of the Ag@AgX based photocatalysts. The photocatalysts, developed by the candidate, showed high performances in environmental remediation.

The candidate had firstly introduced a method for the massive production of graphene. Graphene oxide (GO) was used as the precursor and the graphene was obtained through chemical reduction with thiourea dioxide (TDO) as the reductant. The C/O ratio of the TDO reduced graphene was found to be 5.9 (which was comparable with the ratio for graphite) with a yield ratio of above 99%. This converting efficiency is much higher than that of the efficiency under the identical experimental conditions by using L-ascorbic acid as the reductant. Furthermore, for stabilizing the graphene sheets during the Ag@AgX based photocatalyst production, the candidate had developed a PDDA-based *in situ* stabilization approach (PDDA: poly(diallyldimethylammonium chloride). During the photocatalyst performance studies, the candidate observed new insights into the unique photocatalytic properties of the PDDA-stabilized Ag@AgX/graphene hybrid nanoparticles. Moreover, the candidate had created a novel, cubic shaped Ag@AgX@graphene photocatalysts via the GO sheet-assisted assembly protocol, where GO acted as an amphiphilic template for hetero-growth of AgX nanoparticles. A morphology transformation of AgX nanoparticles from sphere to cube-like shape was accomplished by involving GO. Under UV irradiation, the reduction of GO to graphene and the generation of Ag nanocrystals on AgX occur simultaneously. The as-prepared Ag@AgX@graphene nanocomposites were employed as stable plasmonic photocatalysts to decompose acridine orange as the typical dye pollutant under sunlight. The candidate demonstrated experimentally that when graphene was employed in the photocatalysts, the decomposition efficiency was enhanced by ~50%. In comparison with the bare quasi-spherical Ag@AgX, such graphene-interfaced Ag@AgX displayed a distinctly higher adsorptive capacity, smaller crystal size and reinforced electron–hole pair separation owing to the interfacial contact between Ag@AgX and graphene, resulting in an enhanced photocatalytic decomposition performance. This study provided new avenues for the assembly of morphology-controlled plasmonic photocatalysts with sunlight as the energy source.

In conclusion, the candidate showed familiarity with, and critical understanding of the relevant literatures; the methods adopted were appropriate to the subject matter and properly applied; the research findings were suitable set out, accompanied by adequate exposition and discussion, and the quality of English and the general presentation were satisfactory. The recommendation of the examination committee was that “the degree be awarded”.