論文 / 著書情報
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題目(和文)	近赤外光応答性アップコンバージョンナノ粒子／アナターゼ型TiO2複合エアロゲルに関する研究
Title(English)	Study on NIR-Responsive Upconversion Nanoparticles/Anatase TiO2 Composite Aerogel
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The topic of this thesis is [Study on NIR-Responsive Upconversion Nanoparticles/Anatase TiO_2 Composite Aerogel] and this thesis is composed of 5 Chapters.

Chapter 1 [General Introduction] describes TiO_2 photocatalyst development for environmental purification and technological backgrounds of TiO_2 aerogel and UCNPs, as well as identifies the related problems, further specific research objectives and originality.

Chapter 2 [Synthesis of Anatase TiO_2 Aerogel] provides an optimum synthesis process to synthesize anatase TiO_2 aerogel with high specific surface area using a green and easy chemical process for further fabrication of UCNPs/TiO_2 composite aerogel. TiO_2 aerogel network structure is synthesized through controlling hydrolysis and condensation reaction of TTIP in ethanol. The hydrolysis reaction rate was fixed by controlling at the same amount of acetic acid and water so the hydrolysis reaction time is an important factor for adjusting degree of hydrolysis. The time for hydrolysis reaction and condensation reaction could be controlled by gelating time. If the TiO_2 gel is formed which it also means that the TiO_2 network structure was formed, the hydrolysis reaction and condensation reaction are almost finished and the degree of hydrolysis reaction can not be altered anymore. Thus, if the hydrolysis reaction time is longer, the more OR groups of TTIP can be replaced by OH groups. It can make the TiO_2 network structure completer so that the aerogel structure is easier to be maintained after drastic supercritical drying process which is used for removing ethanol from the gel. At lower temperature of sol-gel process, the gelating time is longer; the hydrolysis reaction time is longer so the degree of hydrolysis is higher and more OR groups can be replaced by OH groups during hydrolysis reaction. Hence, the TiO_2 alkoxides can connect with each other more well to form completer TiO_2 network structure during slower condensation reaction. After the drastic supercritical ethanol drying process, the TiO_2 aerogel structure can be maintained so it exhibits higher specific surface area.

Chapter 3 [Synthesis of UCNPs/Anatase TiO_2 Composite Aerogel] establishes the synthesis process for UCNPs/TiO_2 composite aerogel, and UCNPs of $NaYF_4$:Yb,Ho NPs and $NaYF_4$:Yb,Tm NPs are chosen to synthesize UCNPs/TiO_2 composite aerogels. UCNPs of $NaYF_4$:Yb,Ho nanoparticles (NPs) which can convert the NIR light to visible region are doped into TiO_2 aerogel structure to synthesize NIR-responsive $NaYF_4$:Yb,Ho/TiO_2 composite aerogel. The effects of temperature during sol-gel process and dispersion of $NaYF_4$:Yb,Ho NPs on structure of composite aerogel were investigated. At lower temperature of sol-gel process, the precipitation rate of UCNPs is higher than the formation rate of TiO_2 network structure, and it means that the precipitation of UCNPs before the formation of TiO_2 gel leading to effects on the formation

of anatase TiO_2 aerogel structure. However, the $NaYF_4$:Yb,Ho/TiO_2 composite aerogel can be successfully synthesized at higher temperature of sol-gel process because the formation rate of TiO_2 network structure is faster than precipitation rate of UCNPs. The crystal size, crystal structure and morphology of $NaYF_4$:Yb,Ho NPs can be maintained after doping into TiO_2 aerogel structure. In addition, the characteristics of $NaYF_4$:Yb,Tm/TiO_2 composite aerogel and the effects of doping amount of UCNPs on composite aerogel structure are also investigated. As the doping amount of $NaYF_4$:Yb,Tm NPs increased, the pore size of composite aerogel increased because the bigger UCNPs enlarged the pores after doped into TiO_2 aerogel structure. The upconversion luminescence capability of $NaYF_4$:Yb,Ho NPs and $NaYF_4$:Yb,Tm NPs that exist in the TiO_2 aerogel matrix structure was confirmed.

Chapter 4 [Photocatalytic Activity of TiO_2 Aerogel and $NaYF_4$:Yb,Tm/TiO_2 Composite Aerogel] describes photocatalytic performance of TiO_2 aerogel under UV light irradiation, and the photocatalytic performance of $NaYF_4$:Yb,Tm/TiO_2 composite aerogel under UV and NIR light irradiation. The high specific surface area TiO_2 aerogel with more available sites for capturing useable light and more available pores for chemical reaction exhibited high photocatalytic performance. Additionally, the anatase TiO_2 aerogel still possesses the photocatalytic ability after the $NaYF_4$:Yb,Tm NPs doped into the structure under UV light irradiation. The $NaYF_4$:Yb,Tm/TiO_2 composite aerogel can decompose MB under NIR light irradiation and the TiO_2 aerogel can absorb UV light which transferred from $NaYF_4$:Yb,Tm NPs for photocatalytic activity. Additionally, doping more $NaYF_4$:Yb,Tm NPs into TiO_2 aerogel structure makes more NIR light be transferred to UV regions for TiO_2 aerogel but the distance between anatase TiO_2 crystals and $NaYF_4$:Yb,Tm NPs is an essential factor for photocatalytic activity of composite aerogel.

Chapter 5 [General Conclusions] summarizes the obtained results in the present study and describes the general conclusions.

In this thesis, the synthesis process of TiO_2 aerogel with high specific surface area by controlling condensation rate and the synthesis process of UCNPs/TiO_2 composite aerogel were successfully established. The $NaYF_4$:Yb,Tm/TiO_2 composite aerogels with a high specific surface area are expected to possess a large contact surface with reactants and increase the number of available sites for photochemical reactions. This novel composite aerogel is potential to be used for selective layer of ceramic membrane for air and water purification.