國立臺北科技大學
資源工程研究所

碩士學位論文

利用淨水污泥與燃煤飛灰合成無機聚合材料之研究

A Study on Synthesis of Geopolymeric Materials Using Water Treatment Sludge and Coal Fly Ash

研究生：沈佩玲

指導教授：柯明賢

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摘　要

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本研究將淨水污泥混合燃煤飛灰與鹼性溶液合成無機聚合材料，探討不同添加比例、淨水污泥粒徑大小及淨水污泥培燒溫度與時間對於無機聚合材料之抗壓強度、物理性質、熱傳導性質及其顯微結構之影響，並進一步以矽、鋁溶出試驗探討原料之溶出 Si/Al 比對無機聚合材料之影響。由研究結果顯示，以添加 10% 經 950℃培燒 6 小時之淨水污泥混合燃煤飛灰合成之無機聚合材料具有較佳之抗壓強度，其養護至 28 天之抗壓強度為 28.5MPa，可符合卜特蘭一型水泥之規範要求。而由 ^{29}Si、^{27}Al NMR 及 XRD 之分析結果顯示，以淨水污泥混合燃煤飛灰合成之無機聚合材料具有非晶質之三維鋁矽酸鹽架狀結構，主要結晶相為 SiO_2、$(Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$、$Fe_2O_3$ 及 $CaCO_3$。而由 FTIR 分析結果顯示，無機聚合材料中 Si-O-T (T=Si 或 Al) 鍵之非對稱伸張振動吸收峰位於 983~994cm^{-1} 間，且經培燒後之淨水污泥中綠泥石與伊萊石結構被破壞，而使其中矽、鋁離子較易溶解於鹼性溶液，導致無機聚合反應較為完全。由 SEM 顯微結構分析結果顯示，淨水污泥與燃煤飛灰合成之無機聚合材料為表面呈現緻密形態。

另外，由矽、鋁溶出試驗探討溶出 Si/Al 比對淨水污泥合成無機聚合材料之影響的研究結果得知，培燒活化前處理可增加淨水污泥之矽溶出量，然培燒溫度過高(950℃)時則培燒之淨水污泥會產生尖晶石之晶相，阻礙鋁之溶出而使得鋁溶出量下降。添加 10%經培燒溫度為 950℃且持溫 6 小時之淨水污泥混合燃煤飛灰合成之溶出 Si/Al 比為 2.36，較燃煤飛灰之溶出 Si/Al 比 2.25 為高，且所合成之無機聚合材料由於其無機聚合反應較完全，形成較完整之三維鋁矽酸鹽架狀結構，故具有較佳之機械性質。

ABSTRACT

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The aim of this study was to utilize water treatment sludge and coal fly ash to prepare water treatment sludge geopolymer. The effects of content of water treatment sludge, particle size of sludge, calcined temperature and calcined time of sludge to compressive strength, physical properties, thermal conductivity and micro-structure of geopolymer would be investigated and silicate and aluminate dissolving test of water treatment sludge would be evaluated. The results indicated that the compressive strength of geopolymer prepared by water treatment sludge calcination at 950℃ and lasting 6 hours cured after 28 days was 28.5MPa . It would be better and fit the standard of Portland cement. The spectra of ^{29}Si and ^{27}Al NMR implied that there were amorphous aluminosilicate gels coexisting in geopolymer. The XRD patterns showed that the amount of crystallinity present was mainly caused by SiO_2, $(Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$, Fe_2O_3 and $CaCO_3$ phases present in geopolymer. The spectra of FTIR indicated that the vibrational band at 983～994 cm^{-1} was attributed to the Si-O-T (T=Si or Al) asymmetric stretching mode. Besides, the framework

structure of Serpentine Chlorite and Illite in water treatment sludge was destroyed after calcination resulting in silicate and aluminate ions easily dissolved in alkaline solution ,leading to improved geopolymerisation. The microstructures of geopolymer showed that the appearance of geopolymer was compact.

Furthermore, The silicate and aluminate leaching test of water treatment sludge was conducted to evaluate the soluable Si/Al ratio of water treatment sludge with geopolymer .The results showed that calcined water treatment sludge would improved the leaching concentration of silicate, however, as calcination at higher temperature (950℃), and the spinel phase was formed leading to retarding the release of alumiate monomers. The Soluabe Si/Al ratio of geopolymer prepared by water treatment sludge calcination at 950℃ and lasting 6 hours was 2.36, higher than geopolymer prepared by coal fly ash (2.25), as well as fully geopolymerization and form well-structrue three dimension amorphous aluminosilicate, therefore having good properties.