

# 二氧化碳封存環境下對固井水泥碳化層物理與化學性質之影響\*

## A Study of Physical and Chemical Properties of the Corrosion Layer of API G Cements under Different CO<sub>2</sub> Storage Environments

郭俊志<sup>1</sup> ■ 江建豪<sup>2</sup> ■ 向性一<sup>3</sup> ■ 王建力<sup>4</sup>  
C.C. Kuo<sup>1</sup>, C.H. Chiang<sup>2</sup>, H.I. Hsiang<sup>3</sup>, C.L. Wang<sup>4</sup>

以人為方式將CO<sub>2</sub>長期封存於地質構造，為目前各界廣為接受的CO<sub>2</sub>封存技術之一。台灣地區經評估後選定陸上封閉油氣構造為較佳之CO<sub>2</sub>封存場址。但注入之CO<sub>2</sub>與地層水反應形成之碳酸(H<sub>2</sub>CO<sub>3</sub>)，將對井孔的固井水泥產生碳酸化反應。隨時間增加造成水泥材料之力學性質降低，膠結成分破壞，孔隙率與滲透率增加，進而可能造成CO<sub>2</sub>藉由受碳酸化後無封固能力之固井水泥洩漏。

本研究模擬三種配比之固井水泥於模擬井底環境(70°C、20MPa)兩種CO<sub>2</sub>封存狀態下(超臨界狀態、溶於地層水狀態)，分四個反應時間點(0、7、14、28天)，對其反應後固井水泥碳化層物化性質變化進行探討。本研究結果發現添加矽粉與重晶石，可使套管水泥於反應期間產生緻密層，以減緩外部碳酸持續往內層侵蝕。API G級水泥+矽粉與重晶石有較佳之表層力學性質維持，因此有較佳之防止水泥碳酸化而崩解之能力。

**關鍵詞：**CO<sub>2</sub>、API G 水泥、碳化

Sequestration of CO<sub>2</sub> into the geological formation on land is currently considered an optimum sequestration technique in Taiwan area. However, carbon acid generated by the filling of CO<sub>2</sub> in formation water will result in carbonation in cements used in constructing the on-site wells. As time progresses, the mechanical properties of cement-based materials will deteriorate due to the degradation of the cement composition and increase in pores and permeability. Leakages may also occur because of the carbonation of the well cements.

Three types of API G well cements were investigated in this study. Two types of CO<sub>2</sub> storage environments are simulated in the laboratory. The physical and chemical properties in the carbon layer of the cement were observed initially, 7th, 14th, and 28th day during a period of 28 days. This study finds that the addition of silicon powder and barite produces a denser casting layer that slows down the erosion process on the inner layer due to carbon acid. The experimental results show that API G cement with silicon powder and barite has better mechanical properties on the surface, thus better ability to prevent collapse caused by carbonization.

**Key words:** CO<sub>2</sub>, API G, carbonization

### 一、前言

自工業革命以來，能源的需求量益增加，雖提升了人們的生活品質，背後卻伴隨著化石能源使用後所產生的溫室氣體，進而造成全球能源之一<sup>(1-2)</sup>。在各種溫室氣體中，尤其以二氧化碳的產量與影響為最大，因此在無法避免持續使用化石能源的情性之溫室效應與氣候異常。儘管如此，使用化石能源仍是現今與未來，人們最主要的使用況下，二氧化碳的捕獲與封存技術(carbon dioxide capture and storage, 簡稱 CCS)已被各界認為目前較有效之降低二氧化碳產量

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國立成功大學資源工程研究所 <sup>1</sup>博士生 <sup>2</sup>碩士 <sup>3</sup>教授 <sup>4</sup>副教授