Testing the Capturing of Carbon Dioxide Using Flyash-C Additive

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Abstract:

Cement plays a crucial role in the performance and longevity of concrete, oil wells, and CO_2 Sequencing wells. Cement production results in a significant emission of carbon dioxide (CO_2), a potent greenhouse gas. In this study, a combination of dry solid ice, water, and type C fly ash was stirred for 60 seconds with the addition of either 3% or 10% dry ice. The Carbon Dioxide, Chloride, and Calcium Probes were used to measure the concentrations of CO_2, Cl^-, and Ca^{2+} in solutions. Results showed that 3% Class C fly ash had the ability to reduce CO_2 concentration by 100% in just 5 days. In addition, measuring the electrical resistance of specimens provides accurate CO_2 measurements, enabling the monitoring of changes in cementitious solutions

1. Introduction:

The rapid increase in carbon dioxide emissions globally is due to the growth of industrial activities and population (Meng, et al., 2014). Cement is the most widely manufactured material, with over 4 trillion tons manufactured yearly to support construction and storage (Meyer, 2005). The manufacturing process contributes to about 8% of global CO_2 emissions, due to the decomposition of lime to calcium oxide and the burning of fuel such as coal (Mikulčić, et al., 2016). Additionally, other industries contribute to CO_2 pollution, and the recent wildfires have only added to the issue. Efforts to reduce CO_2 pollution include sequestration (storing CO_2 in geological formations) and sealing boreholes with cement (Shukla, et al., 2010).

Currently, the capture of carbon waste gases is limited, with current carbon dioxide capture projects operating with a total capture capacity of 80 million tons per annum, globally (Mumford et al., 2015). The majority of the captured gases are sequestered, and the utilization of gaseous carbon waste is limited to niche applications. Hence there is a need to develop technologies to reduce the CO_2 emission during the processing and manufacturing of cement around the world.

According to ASTM C618-91, fly ash is a fine material produced from the burning of coal powder and carried out of the boiler by flue gases. The properties of fly ash are dependent on the type of combustion, the coal used, and the shape of the ash particles. Different sources of coal produce varying combustion products, affecting the efficiency of fly ash as a soil stabilizer. In this study, fly ash was employed to capture carbon dioxide in combination with a water solution to reduce carbon dioxide emissions in cement plants. Electrical resistivity (ρ) was chosen as the sensing property for cementitious materials after several studies by Vipulanandan et al. (2004, 2013, 2014). The sensing properties of the cementitious materials were quantified using the changes in resistivity.

2. Objective

The main aim of this study is to explore the use of properly formulated fly ash to decrease CO_2 pollution. The specific objectives as follows:

(i) Examining current methods (chemical, physical, biological, and integrated) for reducing CO_2 pollution through the use of fly ash type C.
(ii) Monitoring the carbon capturing using the electrical resistance method.

3.Methodology:

Dry ice, the solid form of carbon dioxide, is often used as it directly transitions from solid to gas without a liquid state. In the study, water was contaminated with carbon dioxide by mixing it with dry ice. Figure 1 displays dry solid ice mixed with water and fly ash type C. A quick 60-second stir ring was used with 3% and 10% of dry ice added to the water. Figure 1 shows the raw materials for the test, which involved adding dry ice to the water for a quick stir ring followed by adding FA additives.

After mixing, cylindrical molds with a diameter of 2 inches and a height of 4 inches were prepared using four conductive wires inserted into all of the molds. The vertical distance between the two wires in each specimen was maintained constant. Carbon Dioxide, Chloride Ion, and Calcium Ion Probes are innovative indicators for measuring CO_2, Cl^-, and Ca^{2+} concentrations in prepared solutions. They function through a structural change that leads to fluorescence resonance energy transfer (FRET) in the presence of ions.

The electrical resistance of the mixed solutions during mixing was measured using an LCR meter. To reduce contact resistances, the resistance was measured at a frequency of 300 kHz using a two-probe method.

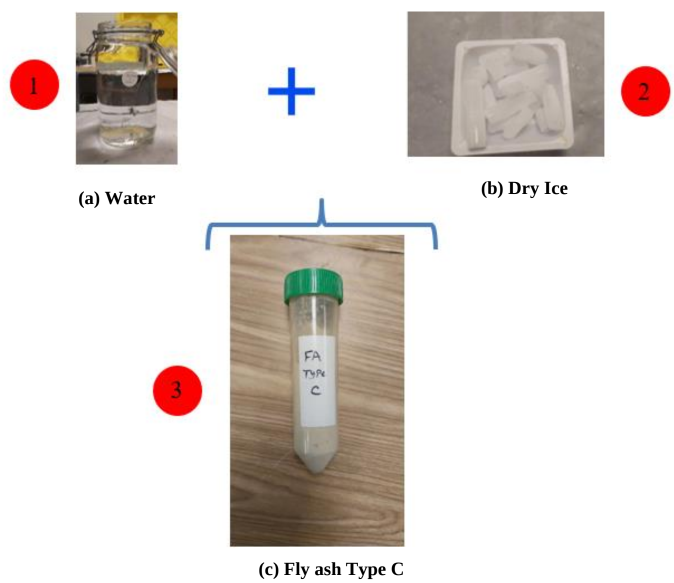
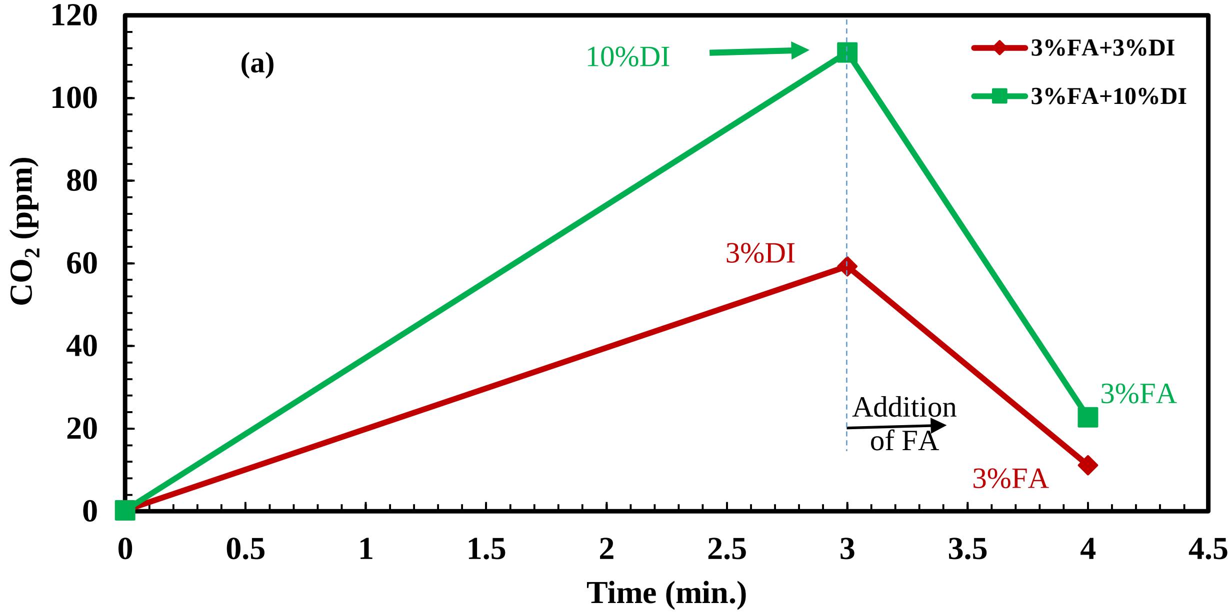


Figure 1 Materials used and mixing procedure: (a) Water, (b) Dry Ice, and (c) Fly ash- C

4. Results and Discussions

Figure 2 shows the CO_2 concentration for two concentrations of dry ice. In this case, The method mentioned earlier was applied by adding 3% and 10% CO_2 to the water, followed by the addition of 3% fly ash (by weight of water). As shown in Figure 2, the CO_2 concentration rapidly increased from zero to around 110 ppm in 3 minutes after adding dry ice. The temperature also decreased from 14°C to 9°C. The addition of 3% fly ash reduced the CO_2 concentration to around 20 and 18 ppm after 1 minute for both 10% and 3% dry ice solutions. After 5 days, the CO_2 concentration dropped to near zero ppm for both cases. The results suggest that Class C fly ash can effectively reduce the CO_2

concentration to nearly 100% in 5 days.



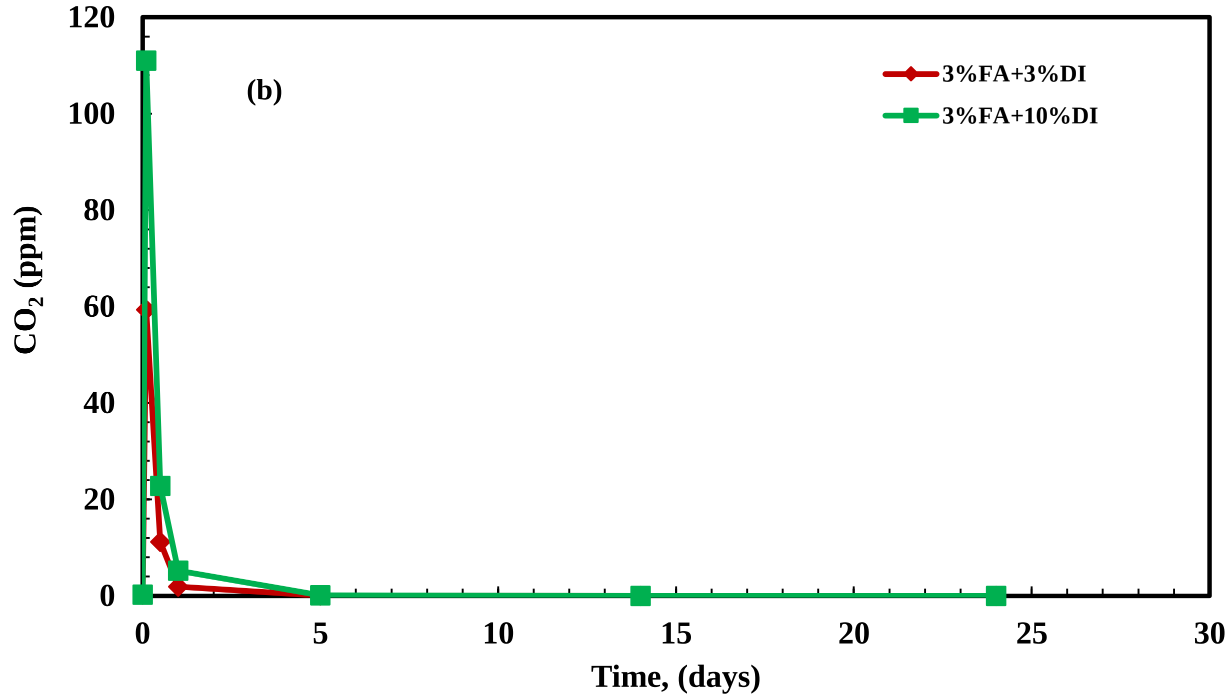


Figure 2: CO_2 concentration of contaminated Class-C fly ash solution (a) initial addition of dry ice, and (b) long-term concentration.

The results of the experiment show that the electrical resistivity is greatly impacted by the addition of 3% and 10% DI. The starting resistance of water was between 1200 to 2000 Ω, but rose sharply to 3000 and 3500 Ω respectively, when 3% and 10% were added. However, after adding 3%FA, the resistance dropped to less than 500 Ω in both cases.

5.Conclusion

From this study, the following conclusions are advanced:

1. One way to decrease emissions from cement factories is by utilizing local and supplementary cementing materials (SCM), such as fly ash.
2. Class C fly ash can decrease the concentration of CO_2 to about 100% in 5 days.
3. Determining the electrical resistance of samples allows for precise measurement of CO_2 levels, facilitating monitoring of changes in cementitious solutions.

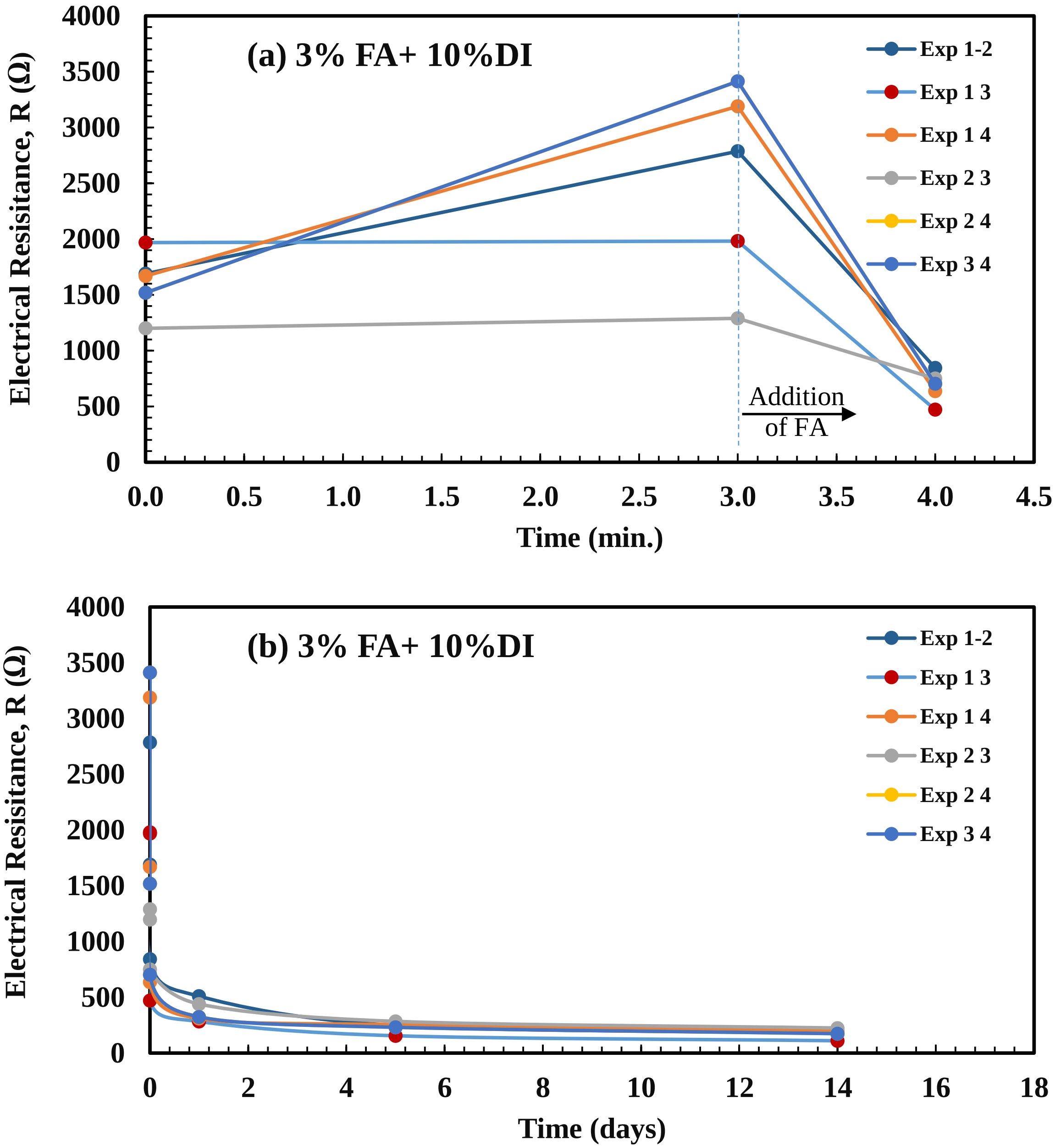


Figure 3 Electrical resistance measurements of contaminated solution (3%FA + 10% dry ice) during (a) 4 minutes, (b) 14 days.

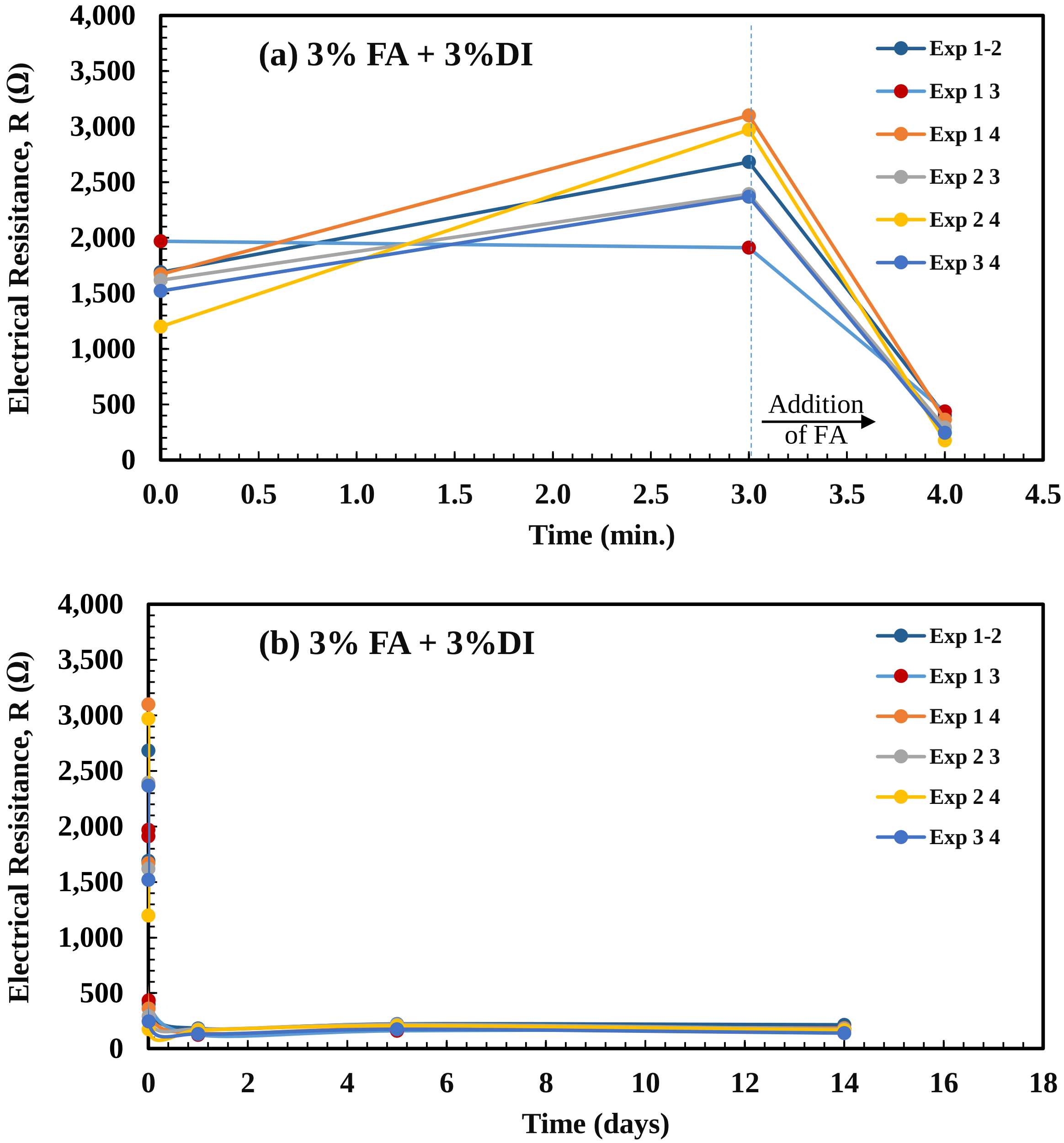


Figure 4 Electrical resistance measurements of contaminated solution (3%FA + 3% dry ice) during (a) 4 minutes, (b) 14 days.

6. Acknowledgments:

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7. References

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