

Investigations of Copper Interference on the Colorimetric Determination of Zinc by Microfluidic Analytical Method

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ABSTRACT

The paper-based microfluidic analysis adopted for this study is an analytical method that offers a growing set of tools for influencing small volumes of fluids to control analytical physical processes that are relevant to sensing as the world advances. This study revealed the levels of Cu²⁺ interferences during the colorimetric detection of Zn²⁺ on the Paper-based Analytical Device (μPADs) in microliter quantities. The μPADs was equipped with target analytes at different concentration of zinc and copper ranging between 10-30μM standard solutions to achieve sufficient detection sensitivity for environmental monitoring. The Zn²⁺ - Zincon reactions, Cu²⁺ - Zincon reactions, and Zn²⁺ - Cu²⁺- Zincon reactions immobilized with Poly Diallyl Dimethyl Ammonium chloride (PDDA) were monitored respectively. The respective reactions resulted in visible colour changes on the μPADs and were then analyzed using the ImageJ software. A slight decrease in the colour intensity occurred during the reaction of Zn²⁺ 1mL of 20uM with 1mL of 10uM of Cu²⁺ standard solutions with Zincon immobilized with PDDA on the paper-microfluidic device. The investigations revealed a negligible effect of copper on zinc-zincon reactions. This study brings to bear an efficient and fast method for monitoring and detecting other analyte interferences with the target analyte in water samples.

Key Words: *microfluidic; analysis; Zinc; copper; zinc-zincon; water analysis*

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INTRODUCTION

- Several methods are employed in industrial testing of metal-metal interferences during water analysis in other to get an accurate result of the target analyte.
- Wastewater treatment effectiveness is based on the result of chemical analysis of water parameters in line with regulatory limits.
- Several studies have revealed that state that most of the copper found in wastewater originates from corrosion of the copper in private piping systems and high levels of copper also do appear in drinking water conveyed through relatively new copper piping systems.
- This work entails the investigations of copper interferences during zinc analysis in water samples using a Paper-based microfluidics analytical method.

MATERIALS AND METHODS

MATERIALS

- Fabricated paper-based microfluidic analytical devices
- Zincon (monosodium salt)
- Zinc Sulphate (ZnSO₄)
- Copper Chloride (CuCl₂)
- Polydiallyldiamethyl ammonium chloride (PDDA)

METHODOLOGY

- Investigation of Copper Interference on Zinc Zincon Reactions on Paper microfluidic devices.
- Reaction Protocol: zinc and copper standard solutions with varying concentrations.
- Triplicate determinations of Zincon- Zn²⁺ reactions were done in each reaction zone of the fabricated μPADs immobilized with PDDA using 6uL zincon (0.1M) and 6uL PDDA (0.1M) was added (at 30minutes interval after drying) and subsequently the respective analyte solutions were added to the reaction zones.
- Image analysis was done using Image J software without conversion. The Image capturing and analysis were taken at 30minutes intervals.,
- The blue channel was used as the internal standard, and the intensity values of the respective concentration were also compared with the blue standard.

RESULTS AND DISCUSSION

- The results of the colorimetric assays on the paper devices (after the blue colour was formed) were captured using a camera phone after four hours and downloaded into a computer for image analysis with the Image J software using the RGB colour mode.
- The bar graph under optimum conditions was found between the blue colour intensity. The blue colour standard was obtained from a representative in the square region located in each spectrophotometric cell of the paper devices.

TABLE 1: IMAGE ANALYSIS DATA AT FROM 0 SECOND - 90 MINUTES

STANDARD CONCENTRATIONS	0-SECONDS	30-MINUTES	60-MINUTES	90 MINUTES
Blue Standard	74.55	74.55	74.55	74.55
Blank	101.40	101.40	101.40	101.40
Cu ²⁺ (10uM)	164.14	158.7	166.60	175.80
Cu ²⁺ (20uM)	165.10	159.5	167.00	176.40
Zn ²⁺ 8uM	168.95	170.4	175.50	186.01
Zn ²⁺ (8uM) + Cu ²⁺ (10uM)	170.79	165.9	172.80	183.80
Zn ²⁺ (8uM) + Cu ²⁺ (20uM)	169.90	167.8	167.80	181.70

- Fig 1-4 shows bar graphs of mean colour intensities against Zn²⁺ / Cu²⁺ Standard Solutions at different concentrations added to the reaction zones respectively at time interval. The data was obtained from image analysis of the triplicate determinations of Zincon- Zn²⁺ reactions.

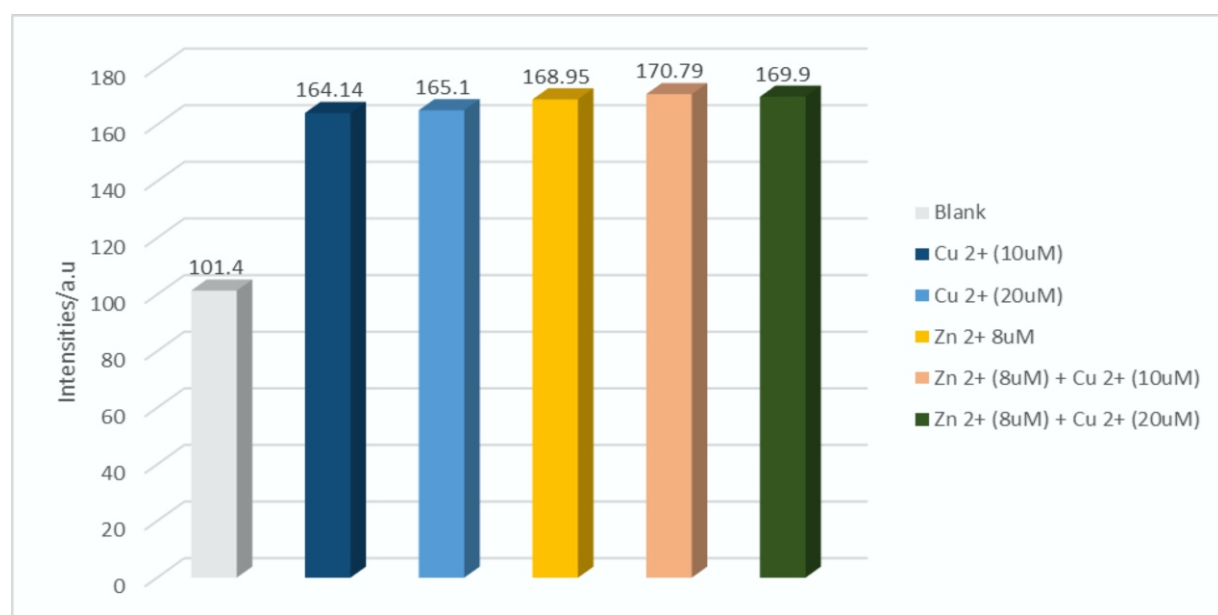


Fig 1: BAR GRAPH ANALYSIS AT 0-1 MINUTE

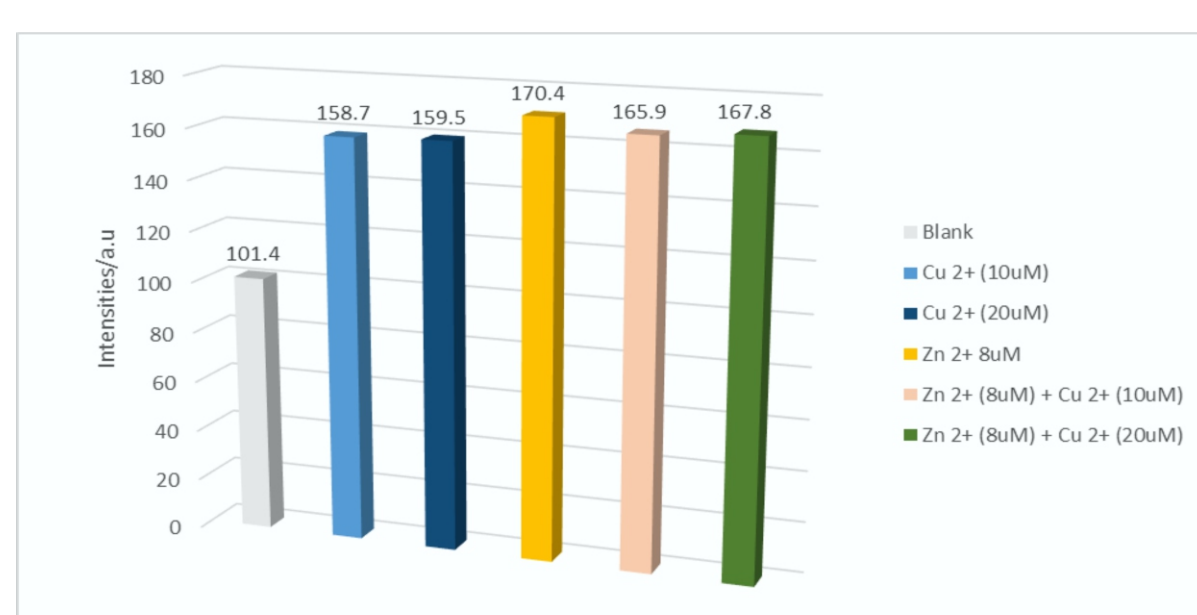


Fig 2: BAR GRAPH ANALYSIS AT 30 MINUTES

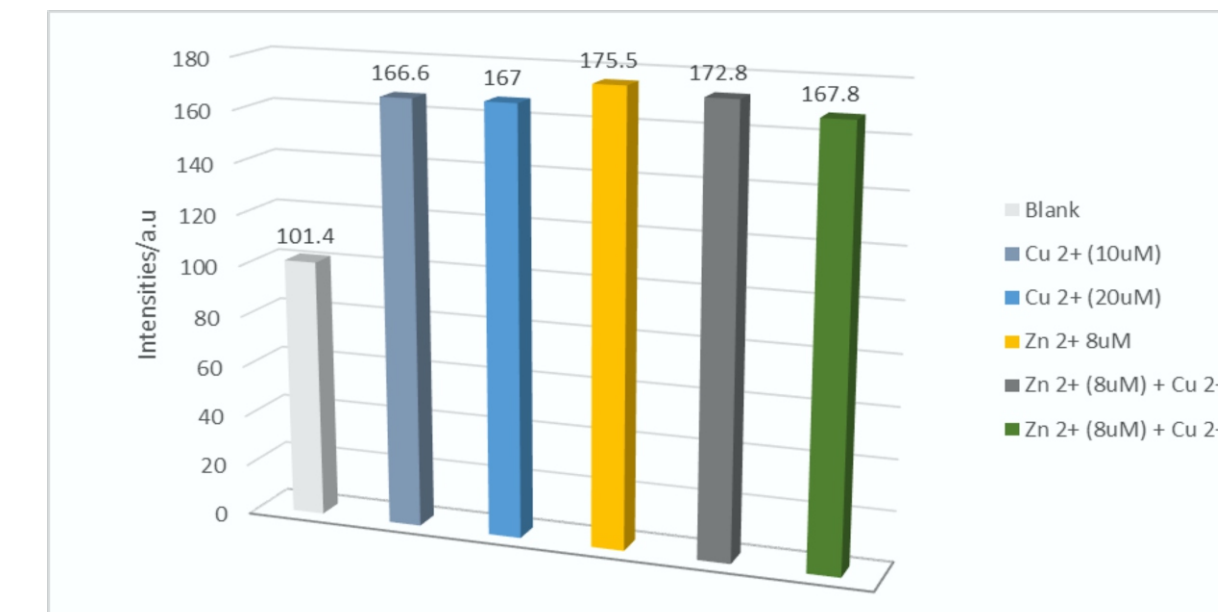


FIG 3: IMAGE ANALYSIS DATA AT 60-MINS

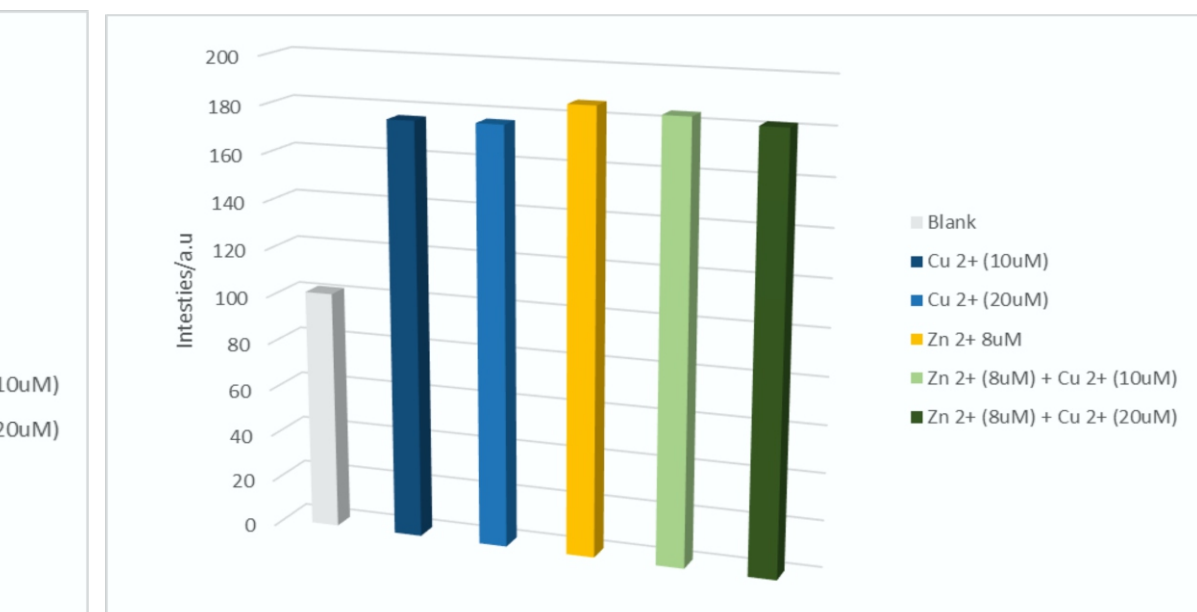


FIG 4: IMAGE ANALYSIS DATA AT 90-MINS

- As seen in the data obtained from the image analysis in table 1 as represented in the bar graphs and plots, revealed a shift/decrease in the colour intensities of the different standard concentration.
- Data obtained immediately after the reaction of the standard solutions with zincon on the μpads showed a slight shift in the intensities of 1.84a.u of 8uM Zn²⁺ with 10uM Cu²⁺ standard solutions and 0.95a.u of 8uM Zn²⁺ with 20uM Cu²⁺ standard solutions in each reaction zones of the μpads respectively.
- A constant increase in intensities was observed from 0-90mins ranging from 169.90 -181.70a.u using 8uM Zn²⁺ with 20uM Cu²⁺. A significant drop in intensities was observed at 60 minutes from 170.79 to 165.9a.u which later increased at 60; 90minutes. See Table 1.
- The time graph shows the significant interference of Cu²⁺ on during Zn²⁺ analysis as time progresses, see Fig 5. The result from this study shows a high level of mutual interference of Copper during Zinc analysis.

- Literature has revealed that older piping systems typically deliver lower copper levels in their drinking water.
- Drinking water is very essential and it's not the only media of concern for high copper levels and water samples showing high level of must be disposed of as hazardous waste instead of reused.
- High levels of copper concentrations are also found in the effluent and sludge produced by wastewater treatment plants hence it's essential for routine monitoring via quick analysis as presented in this study through the Paper-based Microfluidic Analytical Method.

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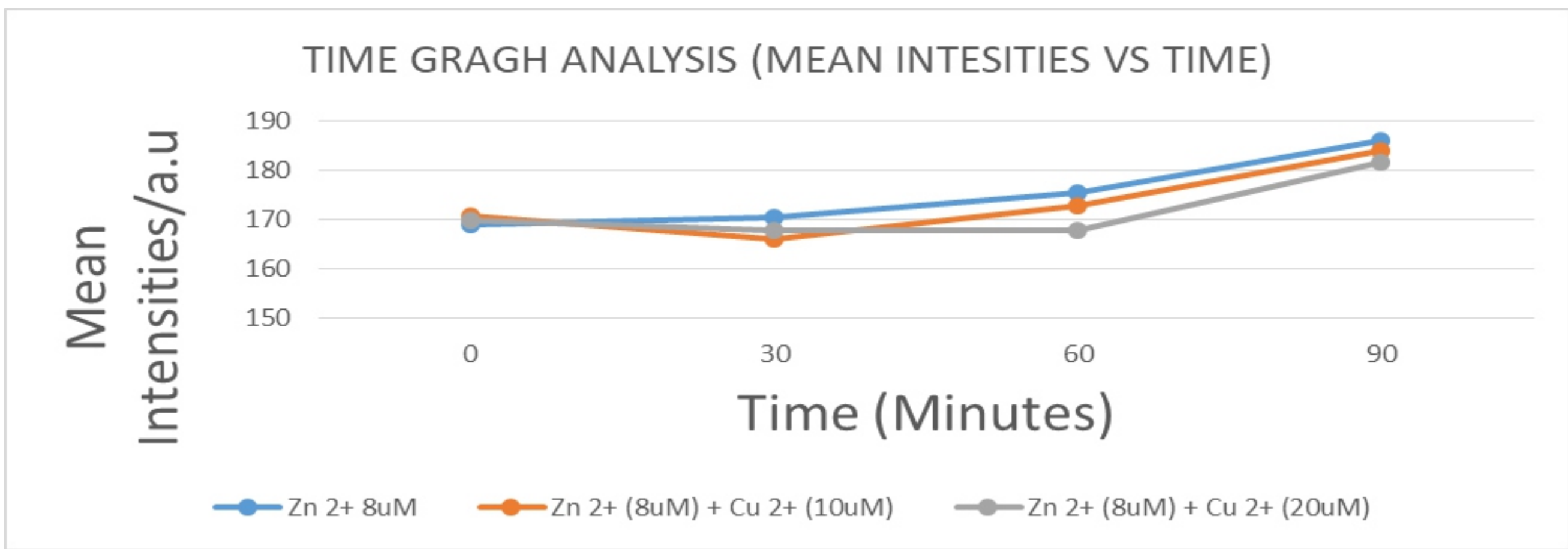


Fig 5. TIME GRAPGH IMAGE ANALYSIS