

**AGING AND COPPER CORROSION BY-PRODUCT RELEASE:
ROLE OF COMMON ANIONS,
IMPACT OF SILICA AND CHLORINE, AND
MITIGATING RELEASE IN NEW PIPE**

Kimberly A. Powers

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Marc Edwards, Chair
Andrea Dietrich
Dan Gallagher

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Aging and Copper Corrosion By-Product Release: Role of Common Anions, Impact of Silica and Chlorine, and Mitigating Release in New Pipe

Kimberly A. Powers

ABSTRACT

It is desirable to reduce leaching of copper from home plumbing because of environmental concerns and to comply with stringent regulation of copper in wastewater and drinking water. The solubility of the scale (oxidized copper rust layer) on the copper pipe wall, which directly contacts drinking water, is a key factor controlling the maximum soluble copper release. Gradual replacement of soluble Cu(OH)₂ scale to less soluble scale is desirable and occurs through a process known as “aging.”

The presence of sulfate, bicarbonate and orthophosphate in water can quickly convert Cu(OH)₂ to less soluble solids. In some cases, this produces a desirable short-term reduction in copper solubility, but over longer time periods formation of these solids can be detrimental because they interfere with formation of very low solubility tenorite (CuO) or malachite phases. Likewise, silica present in water can sorb to Cu(OH)₂ and hinder aging to low solubility tenorite, while the presence of chlorine can hasten aging by a chemical reaction with cupric species that has never been previously observed in the drinking water field. Mild chemical treatments that might be used to accelerate aging, and which could be applied to reduce environmental impacts of newly installed copper pipe, were successfully tested. Chemical pretreatments using lime, caustic, soda ash or chlorine reduced copper release by as much as 84% compared to new pipes without pretreatment.

DEDICATION

“ A Patience Poem for the Child that is Me”

Be patient child,
Be patient, quiet.
The rivers run into the center
 of the earth
 and around
 revolve all things
 and flow
 into the center.
Be patient, child,
 quiet.

Simon Ortiz

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AUTHOR'S PREFACE

This work combines elements of the Virginia Tech manuscript format with the traditional thesis. Traditional elements include a literature review in each section, as well as in the Introduction which is Chapter One of the thesis. Chapter I, III, and IV compose the final report for the Copper Development Association. A shortened version of Chapter IV will be submitted to *Materials Performance*. Chapters II and III are complete manuscripts written for submission to *Environmental Science & Technology*.

TABLE OF CONTENTS

LIST OF TABLES.....	x
LIST OF FIGURES.....	xi
CHAPTER I. INTRODUCTION.....	1
Literature Cited.....	5
CHAPTER II. THE ROLE OF PIPE AGING IN COPPER CORROSION BY PRODUCT RELEASE.....	6
Introduction.....	6
Materials and Methods.....	8
Results and Discussion.....	10
Cupric Ion Precipitation in the Presence of Target Anions.....	10
Impacts of Added Anions on Preformed Cu(OH)2.....	12
In-depth Examination of Sulfate Effects.....	15
General Conceptualization for Copper Corrosion By Product Release.....	18
Conclusion.....	20
Acknowledgements.....	21
References.....	22
CHAPTER III. THE ROLE OF SILICA AND CHLORINE IN CUPRIC HYDROXIDE AGING.....	22
Introduction.....	22
Materials and Methods.....	23
Rate of Base Addition and Copper Solubility.....	23
Sorption of Silica to Copper.....	24

Measurements for Determination of Silica Sorption Density.....	25
Zeta Potential, X-Ray Analysis, and Free Chlorine.....	26
Results and Discussion.....	26
Reaction of Silica with Cupric Hydroxide.....	26
Sorption Density.....	26
Sorption and Zeta Potential.....	28
Transition Time of Cu(OH) ₂ to CuO.....	28
Effects on Solubility, Particle Size, and Deposition to Plasticware.....	29
Reaction of Chlorine with Cupric Hydroxide.....	30
Acknowledgements.....	32
Literature Cited.....	32
Figures.....	33
CHAPTER IV: USE OF CHEMICAL PRE-TREATMENTS to MITIGATE COPPER BY PRODUCT RELEASE.....	42
Introduction.....	42
Materials and Methods.....	44
Phase I: Mild Pre-treatments to Accelerate Pipe Aging.....	45
Phase II: Resistance of Pre-Passivated Pipe to Sulfide Attack.....	46
Statistical Testing.....	46
Results and Discussion.....	47
Phase I: Mild Pre-treatments to Accelerate Pipe Aging.....	47
Phase II: Resistance of Pre-Passivated Pipe to Sulfide Attack.....	48
Acknowledgements.....	49

Literature Cited.....	49
Figures.....	51
VITA.....	58

LIST OF TABLES

2-1.	Solids formed when cupric hydroxide in presence of indicated anion.....	11
2-2.	Summary of results with variable initial sulfate.....	16
3-1.	Solids identified by x-ray diffraction (XRD).....	25
3-2.	Percent chlorine or Cu(OH) ₂ solid loss accounted for by indicated reaction.....	31
4-1.	Drinking water synthesized for research.....	44

LIST OF FIGURES

1-1.	Scale dissolves from a pipe surface, leading to soluble metal in drinking water.....	3
1-2 .	Reaction time versus soluble copper as Cu(OH) ₂ ages to CuO.....	4
1-3 .	Soluble copper as a function of pH.....	4
2-1.	Soluble copper in the presence of the indicated anion.....	14
2-2.	Soluble copper concentration after the addition of the anion to Cu(OH) ₂	14
2-3.	Incorporation of sulfate in the solid.....	16
2-4.	Initial sulfate versus soluble copper	17
2-5.	Simplistic model of equilibrated soluble copper in the presence of various scales.....	20
3-1.	Sorption density for cupric hydroxide solids as a function of silica and pH.....	33
3-2.	Zeta potential for cupric hydroxide solids containing varying concentrations of silica and chlorine at varying pH values.....	34
3-3.	Transition time for solids at varying pH values (above) and containing varying concentrations of silica (below).....	35
3-4.	Digital picture of six solutions containing 0-15 mg/L as SiO ₂	36
3-5.	Digital picture of 12 solutions containing chlorine, silica, and varying pH.....	37
3-6.	Digital picture of solutions and filters with silica and chlorine at pH 7.....	38
3-7.	Soluble copper at pH 7 for four solutions with 0-30 mg/L as SiO ₂	39
3-8.	Free chlorine versus time for solutions with and without chlorine and silica at pH 7 and pH 9.....	40
3-9.	Soluble copper versus time for cupric hydroxide solutions containing chlorine with and without silica t pH 7 and pH 9.....	41

4-1. Total copper concentration in waters produced during pipe treatment using mild chemical solutions.....	51
4-2. Total copper release for five different conditions when pipe is treated before exposure (pre-treatment) and after exposure (post-treatment).....	52
4-3. Percent decrease in total copper release at pH 6.3 when pipes are treated after installation (post) versus before installation (pre).....	53
4-4. Effects of silica on total copper release at pH 9.2 with and without sulfides.....	54
4-5. Pre-treatment versus total copper release in pipes containing 10 mg/L sulfides at pH 6.3 and pH 9.2.....	55
4-6. Percent soluble copper after exposure to different waters at pH 6.3 and pH 9.2.....	56