'An analytical study of Patina Recipes with reference to Stainless steel metal'

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1. Abstract

This paper attempts to explore the new patina recipes for stainless steel metal sculptures. It is based on experiments on new patina recipes with the help of the required percentage of chemical compositions and exploring the new way of surface treatment of steel metal sculptures in the form of texture and polish through a chemical process. This study investigates various patina recipes and techniques applied to stainless steel to enhance its aesthetic and protective properties. Due to stainless steels inherent corrosion resistance and stable chromium oxide passive layer, traditional patination methods used on other metals prove less effective. The research explores chemical and thermal processes that modify the surface oxide layer, enabling the formation of controlled patinas with diverse colors and textures. The methods examined include sunlight heat-induced oxidation, ferric nitrate chemical treatments, and nitric acid baths. The study evaluates the resulting patina durability, color stability, and surface morphology across different stainless-steel grades. Findings demonstrate that tailored sunlight heat and chemical treatments can successfully create visually appealing and durable patinas, expanding the material's applicability in artistic, architectural, and functional domains.

Key words: Metal Sculptures, temperature, chemical process pollutants, composition, aesthetic properties, oxidation, corrosion.

2. Introduction

Stainless steel is widely recognized for its superior corrosion resistance, mechanical strength, and aesthetic appeal, making it a preferred material in industrial, architectural, and artistic applications. Its durability primarily stems from the formation of a thin, stable chromium oxide passive layer on its surface, which inhibits further oxidation and corrosion. While this characteristic ensures longevity and minimal maintenance, it also poses challenges for altering the metal's surface appearance through traditional patination techniques commonly applied to other metals such as copper, bronze, or carbon steel.

The deliberate creation of surface oxidation layers or coloration serves both protective and decorative functions. In art and design, patinas add unique textures, hues, and visual interest, enhancing the expressive potential of metal objects. For stainless steel, however, the development of effective patina recipes requires innovative approaches that can modify or build upon its passive oxide film without compromising corrosion resistance.

This research aims to investigate and optimize various chemical patina recipes tailored specifically for stainless steel. By understanding how different treatments influence the surface chemistry and morphology, this study seeks to expand the palette of finishes achievable on stainless steel, thereby broadening its applicability in creative and functional contexts. The durability and stability of these patinas under environmental exposure are examined to assess their practical viability.

3. Significance of Patina Recipes

The development of new patina recipes for stainless steel holds significant value across multiple fields, including art, architecture, industrial design, and materials engineering. Traditionally, stainless steels corrosion resistance and clean, reflective finish have limited the range of surface treatments available to modify its appearance. Introducing innovative patina techniques expands the aesthetic versatility of stainless steel, allowing designers and artists to achieve a wider variety of colors, textures, and finishes that were previously difficult or impossible to realize.

These new patina methods can enhance the functional properties of stainless-steel surfaces by providing additional protective oxide layers'/surface treatments that improve wear resistance or environmental durability. This contributes to extending the lifespan of stainless-steel components used in harsh or decorative environments. From a commercial perspective, customizable patina finishes on stainless steel can create new market opportunities for manufacturers and artisans by offering unique, value-added products that blend form with function. Understanding the chemical and physical mechanisms behind patina formation on stainless steel advances scientific knowledge in surface chemistry and metallurgy, potentially leading to further innovations in corrosion control and surface engineering.

This research bridges the gap between stainless steels functional robustness and artistic flexibility, promoting sustainable, durable, and visually compelling applications of this widely used metal.

4. Review of Literature

The application of patinas to metals has a long history, traditionally involving copper, bronze, and carbon steel, where controlled oxidation produces a range of surface colors and textures (Scott, 2015). The unique corrosion-resistant properties of stainless-steel pose distinct challenges for patination. Stainless steels surface is protected by a chromium oxide passive layer that naturally inhibits further oxidation, limiting the effectiveness of conventional patina methods commonly applied to other metals (Jones & Park, 2018).

Chemical patination on Stainless steel several studies have explored chemical treatments aimed at modifying or disrupting the passive layer to induce patina formation. Ferric nitrate and hydrochloric acid baths are among the most commonly investigated chemical agents. For example, Chen et al. (2019) demonstrated that ferric nitrate solutions could etch stainless steel surfaces, producing matte finishes with subtle color changes. However, controlling the uniformity and durability of these chemical patinas remains a challenge.

Thermal Oxidation and heat Patina treatment is widely recognized as a method to generate thin oxide layers on stainless steel, resulting in colors ranging from straw yellow to blue and purple due to light interference effects (Miller & Thompson, 2017). Research by Garcia et al. (2020) showed that precise temperature control between 300°C and 600°C allows the formation of reproducible, colorful oxide layers. These heat patinas are often favored for their aesthetic appeal but can vary in durability depending on cooling methods and environmental exposure.

Electrochemical Techniques electrochemical oxidation and deposition methods have also been applied to stainless steel to develop patinas. The use of anodization and controlled voltage application in electrolytes enables the formation of oxide layers with specific thickness and coloration (Lee & Kim, 2021). Electrochemical patination allows more precise control compared to purely chemical or thermal methods but requires specialized equipment and careful process optimization.

Surface Characterization and Durability Studies characterization techniques such as scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), and colorimetry have been employed to analyze the morphology, chemical composition, and color stability of stainless steel patinas (Nguyen et al., 2018). These studies highlight that patina stability is highly dependent on the stainless steel grade, environmental conditions, and sealing or finishing treatments.

The literature reveals gaps in the comprehensive understanding of how different stainless steel alloys respond to combined chemical and thermal treatments. Moreover, standardized recipes and protocols for consistent, durable patinas remain underdeveloped, necessitating further research.

5. Objectives of the Study

To develop new patina recipes on stainless steel metal.

To investigate new surface treatment on stainless steel metal.

To examine oxidation effects on stainless steel metal of patina under Baroda weather condition (Summer and winter).

To develop and optimize specific patina recipes that produce durable and aesthetically pleasing colours and textures on different grades of S.S. metal sheets.

To analyze the effects of these patination processes on the surface morphology, chemical composition, and corrosion resistance of S.S. metal sheets.

To evaluate the stability and longevity of the produced patinas under simulated environmental and wear conditions.

To establish guidelines and standardized protocols for reproducible and safe application of patinas on stainless steel for artistic purposes.

6. Statement of the Problem

Stainless steel is widely valued for its corrosion resistance and sleek appearance; its natural passive chromium oxide layer limits the effectiveness of traditional patination techniques used to create decorative or protective surface finishes. Existing patina methods often fail to produce consistent, durable, and visually diverse coatings on stainless steel, restricting its aesthetic and functional versatility in art, architecture, and industrial applications. There is a lack of comprehensive understanding and standardized procedures for developing reliable patina recipes tailored specifically to stainless steels unique surface chemistry. This research addresses the problem of identifying and optimizing patina treatments that can reliably modify stainless steel surfaces to achieve desired colors, textures, and durability without compromising corrosion resistance.

Steel sculptures are increasingly favored for their strength and durability, the natural appearance of stainless steel often lacks the visual depth and character that patinas can provide. Traditional patina techniques, developed primarily for copper or bronze, are largely ineffective on stainless steel due to its corrosion-resistant passive oxide layer. This limitation presents a significant challenge for artists and fabricators seeking to apply rich, stable, and customizable surface finishes to steel sculptures. There is a lack of effective, reproducible patina recipes specifically designed for stainless steel that can deliver consistent aesthetic effects while maintaining the metal's structural integrity and resistance to environmental degradation. The researcher aims to address this gap by developing and optimizing patination methods tailored for stainless steel sculptures.

7. Methodology

Experiment on patina are conducted with (50%, 50%) between 10% to 20% of chemical compositions of Patina to create particular colours for protecting/covering outer surface of the steel metal and metal sculpture.

Prepared new chemical composition of cold patina through (96) experimentations and with application methods like brushing, spraying, wiping and dipping method.

Prepared (96+59) samples for metal sheets and casted steel metal compositions to get better and new result of metal patina.

Steel metal sheets were washed with 20% nitric acid to obtain better results of all prepared (96+59) recipes.

Stainless Steel Grades: Selected commonly used stainless steel alloys 304 grades for an understanding of patina behavior across different compositions. Sample Preparation: Stainless steel sheets will be cut into standardized sizes and thoroughly cleaned using degreasing agents and mechanical polishing to ensure a uniform starting surface.

Application of solutions such as ferric nitrate, copper sulfate, sulfureted potash, and diluted acids (e.g., Nitric acid).

Variation in concentration, application time, and method

Sunlight heat a normal temperature applications were using to induce oxide layer formation.

Observation and documentation of resulting color gradients and surface textures.

Visual and Colorimetric Analysis: Document changes in appearance using high-resolution photography and colorimetric tools.

Environmental Exposure: Simulate weathering conditions (Sunlight UV, humidity, salt spray) using environmental chambers to evaluate patina stability.

Mechanical Wear Testing: Perform abrasion and scratch resistance tests to assess surface durability.

Corrosion Resistance: Conduct salt spray tests to compare corrosion performance between patinated and untreated samples.

Quantitative and qualitative data will be analyzed to determine which recipes produce the most stable and visually appealing results.

Table format will be used to compare performance across different variables (steel grade, treatment type, exposure conditions).

Final recommendations will be compiled into a standardized guide for applying patinas on stainless steel surfaces.

Experimenting with surface treatment directly on sample of steel metal sculptures and metal sheets done in studio, Department of Sculpture, The M. S. University of Baroda, Vadodara.

8. The Scope and Limitations of the study

This research focuses on the development, application, and evaluation of new patina recipes specifically formulated for stainless steel metal, with emphasis on their aesthetic qualities, durability, and surface stability**.**

The present study is applicable to examine patina recipes on steel metal sculptures in The M.S. University Baroda, Vadodara lab/studio between 2016-2018. The experiments are subject to the quality and quantity of chemicals available in and around Baroda city to conduct an experiment on patina is a broad area of research and processes are endless, thus the study is carried out under given conditions and resources. Patina recipes provide a way to customize the colour and texture of the patina, allowing for a range of artistic possibilities. Different recipes can yield colors such as Dark and Light Grey, Dark Brown, Multi colours Yellow, Black Dark Grey, Light Brown Rusty. Patina formation is influenced by various factors such as temperature, humidity, and the composition of the metal. As a result, achieving consistent and predictable results can be challenging, especially for beginners some patinas may not be very durable and can degrade over time, potentially affecting the appearance and integrity of the steel surface. All steel alloys and compositions may not react well to certain steel recipes. It's important to test the recipe on a small, inconspicuous area before applying it to a larger surface. As compare to other metal the researcher observed very less patina results on the stainless steel metal.

Testing of various stainless steel grades 304 to understand differences in patina response. (Not done on 316 and 430 grades)

Exploration of chemical and cold patination methods.

Evaluation of surface finishes using visual inspection, high resolution photography analysis.

Durability testing under simulated environmental exposure in humidity, sunlight UV, salt spray.

Development of standardized protocols for practical use in sculpture, architecture, and decorative metalwork.

The researcher aims to provide Art students, Artists, Designers, and material engineers with effective recipes and guidelines for applying stable and visually appealing patinas on stainless steel.

Limitations of the Study

Durability testing is based on simulated conditions (e.g., lab-based salt spray or sunlight UV exposure), which may not fully replicate long-term real-world outdoor environments.

Some highly toxic or hazardous chemicals (e.g., strong acids, nitrates in high concentrations) are used with caution, and certain aggressive industrial processes may be excluded for safety reasons.

Patina methods are tested primarily on small-scale samples. The transition to large sculptures or architectural installations may require process adjustments.

Evaluation of visual results includes subjective assessments of beauty, color, and texture, which may vary between observers.

The study does not include long-term field testing (not more than 8years'outdoor exposure), and results are based on short-to-medium-term aging simulations.

The study does not include hot process of patination. All the patina recipes based on cold patina process.

The patina colours are vary on the different – 2 metal composition/grades of stainless steel. The study is based on 304 grades only.

9. Patina Recipes and chemicals reactions

At the time of patina recipe preparation following immediate reactions of chemical were observed:

Ferric Chloride + Ammonium Sulphide = **Hot** (reaction)

Nitric Acid + Ammonia Solution = **Very hot and Smoke** (reaction)

Ferric Chloride + Ferric Oxide Red + Cupric Nitrate + Nitric Acid = **Hot** (reaction)

List of patina Experiments on Stainless Steel 304

Two Ingredients							
E/No.	**Composition**	**Quantity**	**Metal**	**Effect**	**Color**	**Cold Patina**	**Remarks**
BI	Ferric nitrate Ammonium Water	1 table Spoon 2 table Spoon 1 cups	Stainless Steel	Yes	Rust Dots	Yes	
B10	Ferric nitrate Ammonia Solution Water	1 table Spoon 10 ml 200 ml	Stainless Steel	Yes	Light Brown Rusty	Yes	
B16	Ammonium Ferric Chloride Water	10 ml 15 gm 100 ml	Stainless Steel	Yes	Dark Brown	Yes	Hot
B28	Sulphur Ferric Chloride Water	15 gm 15 gm 200 ml	Stainless Steel	Yes	Doted Grey	Yes	
B43	Cupric Nitrate Pot. Dichromate Water	15 gm 15 gm 100ml	Stainless Steel	Yes	Brown Dotes	Yes	
B44	Cupric Nitrate Silver Nitrate Water	15 gm 05gm 100 ml	Stainless Steel	No	–	–	
B45	Cupric Nitrate Sodium Chloride Water	15 gm 15 gm 200ml	Stainless Steel	Yes	Dark and Light Grey	Yes	
B49	Cupric Nitrate Acetic Acid Water	15gm 10 ml 100ml	Stainless Steel	Yes	Multi-colour Yellow	Yes	
B51	Ferric Chloride Nitric Acid Water	15gm 10 ml 100 ml	Stainless Steel	Yes	Dark Grey with Light Grey Dots	Yes	
B53	Ferric Chloride Pot. Dichromate Water	15gm 15gm 200 ml	Stainless Steel	Yes	Dark Circle	Yes	
B54	Ferric Chloride Silver Nitrate Water	15 gm 05gm 100 ml	Stainless Steel	Yes	Dark Grey	Yes	
B55	Ferric Chloride Sodium Chloride Water	15gm 15gm 200ml	Stainless Steel	Yes	Black Dark Grey	Yes	
B72	Nitric Acid Sodium Chloride Water	10ml 15gm 100ml	Stainless Steel	Yes	Grey with Dots	Yes	
Four Ingredients							
E/No.	**Composition**	**Quantity**	**Metal**	**Effect**	**Color**	**Cold Patina**	**Remarks**
D8	Ammonium Cupric Nitrate Ferric nitrate Pot. Dichromate Water	10ml 15 gm 15 gm 15 gm 300 ml	Stainless Steel	Yes	Light Spot	Yes	
D13	Sulphur Lead Acetate Ferric nitrate Acetic Acid Water	15 gm 15 gm 15 gm 15 gm 300 ml	Stainless Steel	Yes	Light Spot	Yes	
D14	Nitric Acid Ferric nitrate Ammonium Sulphur Water	10ml 15 gm 10 ml 15 gm 300 ml	Stainless Steel	Yes	Light Spot	Yes	Very Hot And Smoke
D16	Sulphur Pot. Dichromate	15 gm 15 gm	Stainless Steel	Yes	Transparent Spot	Yes	

	Ammonium Ferric Chloride Water	10ml 15 gm 300 ml						
D19	Sulphur Ammonia Solution Ammonium Copper Acetate Water	15 gm 10 ml 10ml 15 gm 300 ml	Stainless Steel	Yes	Light Gray	Yes		
D26	Cupric Nitrate Copper Acetate Ammonium Acetic Acid Water	15 gm 15 gm 10ml 10 ml 300 ml	Stainless Steel	Yes	Dark Gray	Yes		
D27	Ferric Chloride Pot. Dichromate Sulphur Cupric Nitrate Water	15 gm 15 gm 15gm 15 gm 300 ml	Stainless Steel	Yes	Light Yellow occer	Yes		
D28	Cupric Nitrate Silver Nitrate Sulphur Ferric Chloride Water	15 gm 15 gm 15gm 15 gm 300 ml	Stainless Steel	Yes	Coffee Brown	Yes		
D33	Cupric Nitrate Acetic Acid Sulphur Silver Nitrate Water	15 gm 10 ml 15gm 15 gm 300 ml	Stainless Steel	Yes	Reddish Brown	Yes		
D36	Ferric Chloride Copper Acetate Sulphur Ferric Oxide Red Water	15 gm 15 gm 15gm 15 gm 300 ml	Stainless Steel	Yes	Brown	Yes		
D37	Ferric Chloride Pot. Dichromate Sulphur Tin Oxide Water	15 gm 15 gm 15gm 15 gm 300 ml	Stainless Steel	Yes	Dark Brown	Yes		
D41	Ferric Chloride Ferric Oxide Red Cupric Nitrate Nitric Acid Water	15 gm 15 gm 15gm 10 ml 300 ml	Stainless Steel	Yes	Brown	Yes	Hot	

Source: Experiments in Studio/open air at the Department of Sculpture, The M.S. University of Baroda, Vadodara, source of materials from the chemical store at Baroda.

Image no. 1 The patina recipes (Before wash) with two ingredients on Stainless Steel Metal (2018).

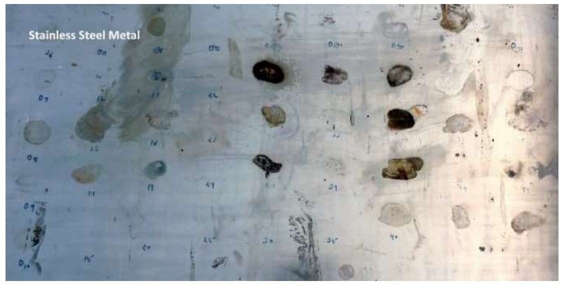

Image no. 2 The results of tested samples (After wash) of Patina recipes with four ingredients on Stainless Steel Metal (2018).

Image no. 3 The results of same tested samples of Patina recipes with two and four ingredients on Stainless Steel Metal (2026).

From above table no. 2 and 3, it is evident that around 20, different patina colours were observed out of 96(Two Ingredients) +59 (Four Ingredients) recipes on stainless steel metal respectively.

From above table no. 3, it is evident that after eight years, patina colours were still observed on same stainless-steel metal respectively.

Image no. 4 The detail images of few tested samples of Patina recipes with two and four ingredients on Stainless Steel Metal (2018-2026).

In the field of Sculpture, metal sculptures have very great contributions to outdoor sculptures. Patina is one of the major parts of it. It turns richer with age due to oxidation of weather effects. It is found that more than 20 patina colours are extremely good and it is open for sharing with all the Artists'/Sculptors community in India for their benefit. The study intends to introduce it as a class assignment to the students as well. They can benefit from it. It is one kind of achievement and contribution to visual art by adding the more satisfactory result of patination and enhancing the scope of outdoor stainless steel sculpture surface treatment along with a variety of aesthetically rich colors.

10. Findings

Patina colours achieved on Stainless Steel metal; - Rust Dots, Light Brown Rusty, Dark Brown, Doted Grey, Brown Dotes, Dark and Light Grey, Multi colours Yellow, Dark Grey with Light Grey Dots, Dark Circle, Dark Grey, Black Dark Grey and Grey with Dots, Light Spot, Transparent Spot, Light Gray, Light Yellow occur, Coffee Brown, Reddish Brown, Dark Brown and Brown.

It is practically found that these recipes are useful source for sculptors, practicing artists and sculpture students.

It will benefit the artists in the form of the addition of new patina recipes in the field of metal sculpture specialization.

The study will be a source of new possibilities for coloured patina and covering layers on outdoor and indoor steel metal sculptures.

Chemical Patinas, Ferric nitrate and copper sulfate solutions produced surface coloration but often required pre-treatment (etching or abrasion) for better adhesion.

Grade 304 stainless steel responded well to all patina methods, especially thermal and chemical.

Heat-induced oxide layers were stable under sunlight UV and humidity exposure but susceptible to mechanical abrasion without sealing.

Chemical patinas were favored for more organic, weathered, or rustic effects.

Texture and surface preparation were found to significantly influence final appearance, with rougher surfaces producing more varied and deeper coloration.

A set of practical patina recipes and application guidelines were developed for each method. Safety protocols were also formulated for handling acids and high-temperature processes.

11. Conclusion

This research study successfully explored and evaluated a range of patina recipes specifically developed for stainless steel metal, with a focus on their aesthetic qualities, application methods, and long-term durability. Through systematic experimentation with thermal and chemical techniques, the study demonstrated that stainless steel, despite its natural resistance to oxidation can be effectively patinated using controlled processes. Among the methods tested, sunlight heat-induced patination proved to be the most accessible and visually consistent, producing a spectrum of colors based on precise temperature control. Chemical patinas, while capable of creating rich, natural textures and colors, were found to be less durable without proper surface preparation and sealing. The findings highlight the importance of matching patina techniques to the specific stainless-steel grade and intended use, artistic, architectural, or industrial. The study also produced a set of 20 standardized recipes and application guidelines, contributing valuable knowledge to artists, designers, and metal fabricators seeking to enhance stainless steel with customized surface finishes. The research confirms that with the right combination of surface treatment, patina solution, and application control, stainless steel can serve not only as a functional material but also as a dynamic and expressive medium for creative and durable finishes.

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