# Tuning Chemical and Physical Characteristics of Tellurate Inorganic Pigments to Control Optical Properties

**Bita Amiri**, Hoa Nguyen, Robin T. Macaluso
Department of Chemistry and Biochemistry, Arlington, TX 76019

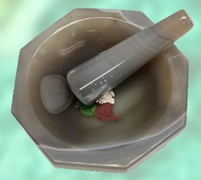
## Introduction

The global inorganic pigment industry is a multibillion-dollar market projected to grow in the coming decades. Inorganic pigments are valued for their stability, vibrant colors, and cost-effectiveness but often struggle with limited color diversity and environmental concerns due to toxic metals. An ongoing challenge is to develop pigments that offer customizable colors while using non-toxic, environmentally safer elements.

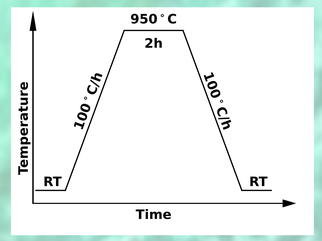
In this study, a series of $LaCrTeO_6$ pigments were synthesized, and Fe was doped into the structure to form the general formula $LaCr_{1-x}Fe_xTeO_6$. Chromium (Cr) and iron (Fe) were chosen for their electronic properties, with Cr providing greenish-blue hues and Fe shifting the spectrum toward pink. Tellurate compounds containing Te(IV) were selected for their stability and lower toxicity compared to other tellurium-based compounds.

## Synthesis of $LaCr_{1-x}Fe_xTeO_6$

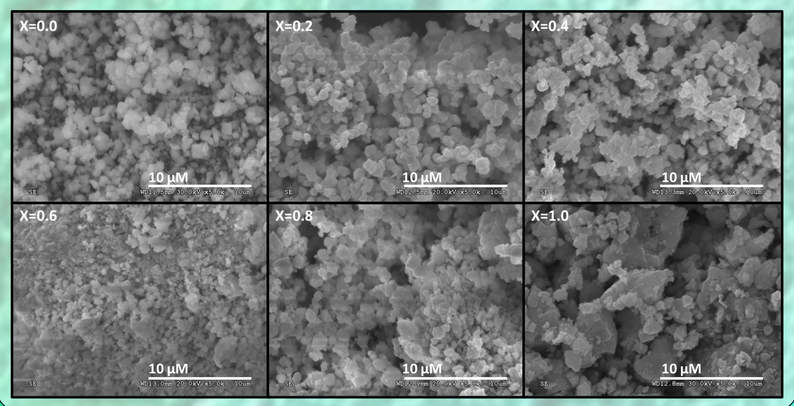
$$La_2O_3 + (1-x)Cr_2O_3 + (x)Fe_2O_3 + 2TeO_2 + O_2 \rightarrow 2LaCr_{1-x}Fe_xTeO_6$$



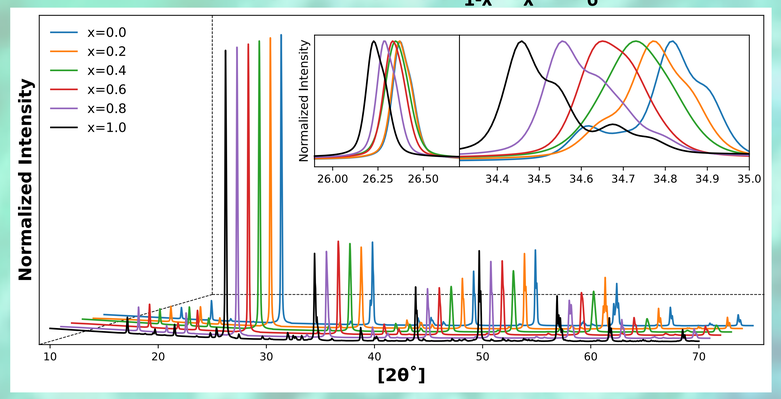
+



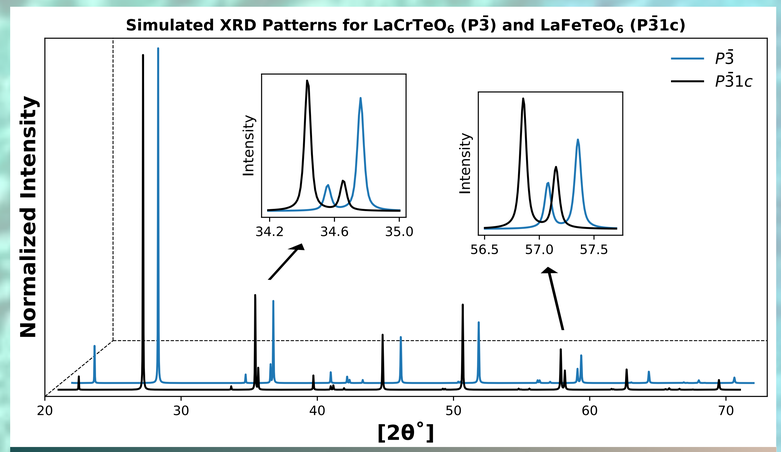

## SEM of $LaCr_{1-x}Fe_xTeO_6$



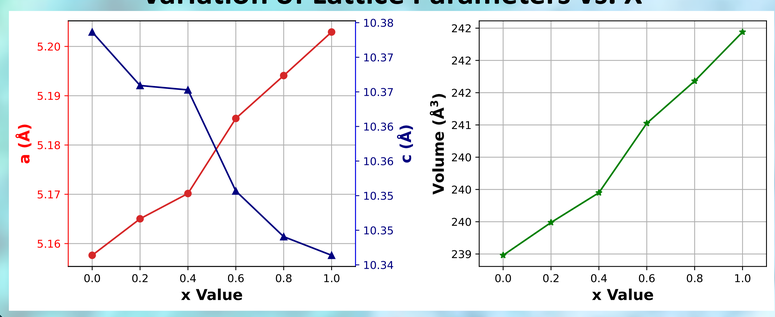

## Powder XRD of $LaCr_{1-x}Fe_xTeO_6$



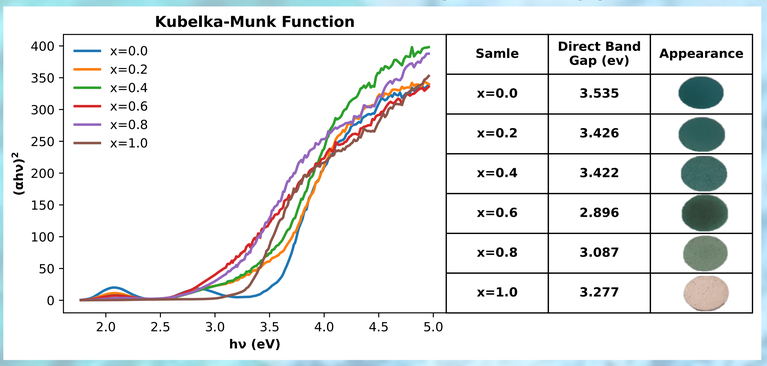

XRD patterns shift to the left with increasing Fe content, in agreement with the larger radius of $Fe^{3+}$ (0.78 Å) compared to $Cr^{3+}$ (0.62 Å). The space groups of $LaCrTeO_6$ and $LaFeTeO_6$ was initially determined. By comparing simulated XRD patterns with experimental XRD patterns, we confirm that $LaFeTeO_6$ crystallizes in $P\bar{3}1c$ and $LaCrTeO_6$ crystallizes in $P\bar{3}$. With increasing Fe content, the unit cell expands in the a-direction and shrinks in the c-direction. Overall, the unit cell volume of $LaCr_{1-x}Fe_xTeO_6$ increases with increasing Fe content.




## Variation of Lattice Parameters vs. X




## Diffuse Reflectance Spectroscopy




| Samle | Direct Band Gap (ev) | Appearance |
|---|---|---|
| x=0.0 | 3.535 | |
| x=0.2 | 3.426 | |
| x=0.4 | 3.422 | |
| x=0.6 | 2.896 | |
| x=0.8 | 3.087 | |
| x=1.0 | 3.277 | |

Different band gap values lead to different colors in samples.

## Conclusion

This study successfully synthesized a series of $LaCr_{1-x}Fe_xTeO_6$ pigments, offering a tunable color range from greenish-blue to pale pink by systematically varying Cr and Fe content. These pigments address significant challenges in the inorganic pigment industry by broadening the available color palette while utilizing less toxic, environmentally benign elements. Comprehensive structural and optical analyses revealed the impact of composition and particle size on color properties and reflectance. The findings provide a foundation for the development of sustainable, color-tunable pigments suitable for diverse industrial applications.

## Reference

1. Popov, Nina, *et* al., *J. Phys. Chem. Solids,* **148**, (2021) 109699
2. Razizadeh, M., *et* al., *Constr. Build. Mater.,* **287** (2021): 123034.

## Acknowledgment

This work was financially supported by NFS, Division of Material Research. Award #: 2113689