

Research Article: Influence of Calcination Temperature on the Surface Properties of ABO₃-Type Rare-Earth Transition Metal Oxides

Jyoti Kumari¹; Rabindra Kumar¹; Vijay Kumar¹; Sima Kumari²

¹University Department of Chemistry, T.M. Bhagalpur University, Bhagalpur-812007, Bihar, India

²Bhagalpur College of Engineering, Sabour, Bhagalpur, Bihar

Publication Date: 2026/09/28

Abstract: Mixed metal oxide perovskites have emerged as an important class of functional materials because of their outstanding structural flexibility, chemical stability, and electronics properties. The general formula of ABO₃ mixed oxide of rare-earth transition metals allows for partial or total substitution at both the A and B sites, allowing for precise control over catalytic activity, electrical conductivity, magnetic behavior, and optical properties. The amount of accessible active sites, adsorption capacity, and mass transport properties are all determined by the BET surface area, which is one of the many parameters that determine their catalytic effectiveness. Particle size, pore distribution, and surface shape are all greatly impacted by variations in synthesis processes, which ultimately alter the catalyst's surface area. This review discusses the relationship between surface area and catalytic efficiency in mixed metal oxide perovskites, with emphasis on photocatalytic and heterogeneous catalytic applications. The mechanisms through which surface area enhances adsorption, charge transfer, and reaction kinetics are also examined. Furthermore, strategies for increasing surface area through nanostructuring, template-assisted synthesis, and defect engineering are summarized. The review highlights the importance of optimizing surface characteristics to improve catalytic performance in environmental remediation and energy-related applications.

Keywords: Mixed Metal Oxide, Perovskite, Surface Area, Photocatalysis, Catalysis, BET Surface Area.

How to Cite: Jyoti Kumari; Rabindra Kumar; Vijay Kumar; Sima Kumari (2026) Research Article: Influence of Calcination Temperature on the Surface Properties of ABO₃-Type Rare-Earth Transition Metal Oxides. *International Journal of Innovative Science and Research Technology*, 11(9), 1652-1655. <https://doi.org/10.38124/ijisrt/26sep802>

I. INTRODUCTION

Mixed metal oxide perovskites constitute an important family of crystalline materials possessing the general chemical composition ABO₃, where A is generally occupied by a rare-earth or alkaline-earth cation and B is typically occupied by a transition metal ion (A = Y, B = Co, Ni). Their crystal framework permits extensive elemental substitution without disrupting the overall lattice symmetry, making them highly adaptable for numerous technological applications^{1,2}.

The catalytic performance of these materials depends on several intrinsic properties, including crystal structure, oxygen vacancy concentration, oxidation states of transition metals, particle morphology, and specific surface area. Among these parameters, the surface area of the samples directly influences the interaction between catalyst and reactant molecules^{3,4}. A higher surface area generally provides a larger number of exposed active sites, thereby improving adsorption and accelerating catalytic reactions⁵.

Recent advances in synthesis techniques have enabled the fabrication of nanostructured perovskites with

significantly enhanced surface areas, leading to remarkable improvements in photocatalytic degradation, water splitting, oxygen evolution reactions, hydrogen production, and electrochemical energy conversion⁶.

- Scope of the Article: Material Science Catalysis

II. MATERIALS AND METHODS

The preparation of mixed metal oxide by solid state decomposition method followed by heat treatment in vacuum^{7,8}. The samples were synthesized or calcined at 700 °C, 800 °C, 900 °C and 1000 °C were labelled as YC₁, YC₂, YC₃ and YC₄ respectively for YC – series, (Where, YC = YCoO₃). And similar procedure was followed for YN – series, (Where, YN = YNiO₃) and labelled as YN₁, YN₂, YN₃ and YN₄ respectively.

- *Types of Mixed-Metal Oxide Perovskite and importance of its Surface Area*

There are several types of mixed-metal oxides with their different physio-chemical properties such as CaTiO₃,

GdCoO₃, LaFeO₃, YCoO₃, YNiO₃ etc. The surface area of any perovskite material strongly influences physicochemical properties or catalytic activity because a larger surface area provides more active catalytic sites, higher adsorption capacity, improved reactant accessibility, enhanced electrical properties⁹. As we know, it is versatile material in the field of material science, it has broad research area and its properties. And several factors which affect the surface area such as decomposition temperature, method of preparation, porosity and particle size. Whereas catalytic reaction begins with different mechanisms in different fields such as adsorption of reactant molecules. An increase in surface area exposes a greater number of adsorption sites leading to improved interaction between molecules and catalyst. And in photocatalytic perovskites, the larger surface area shortens the migration distance of photogenerated electrons and holes. Thereby, decrease in recombination losses and increase in the product of reactive oxygen species. The nanostructured perovskite material having larger surface area often possesses higher concentration of oxygen vacancies which improves the oxygen mobility and facilitates the oxidation and reduction reaction. While a greater surface area exposes more transition – metal ion at catalyst surface, increasing the density of catalytically active sites responsible for the redox reactions^{10,11}.

III. RESULTS AND DISCUSSION

The samples which were calcined at 700 °C, 800 °C, 900 °C and 1000 °C which are YC₁, YC₂, YC₃ and YC₄ respectively for YC (YCoO₃)-series show the variation with the calcination temperature. Firstly, the surface area increases with the increase in calcination temperature till 900 °C and after that surface area decreases at 1000 °C as shown in Fig. 1. And a similar trend was also found in the case of YN₁, YN₂, YN₃ and YN₄ which were prepared at 700 °C, 800 °C, 900 °C, and 1000 °C respectively for YN (YNiO₃)-series as shown in fig.2. The surface area of the samples firstly increases with the calcination temperature to 900 °C and then decreases to 1000 °C. Then, we can observe that the sample prepared at 900 °C shows the maximum values of surface area in both series which are YCoO₃ and YNiO₃. And at maximum calcination temperature at 1000 °C, we obtain the lowest values of surface area in both the cases, for YCoO₃ and YNiO₃. And as shown in fig.3, the surface area at 700 °C, 800 °C, 900 °C and 1000 °C YN-Series shows higher values of surface area than YC-Series. Which also affects the several physio-chemical properties of mixed-metal oxides such as catalytic activity, acidity, and electrical properties. Therefore, we can say that surface area plays a decisive role in physio-chemical properties of mixed- metal oxide^{7,12}.

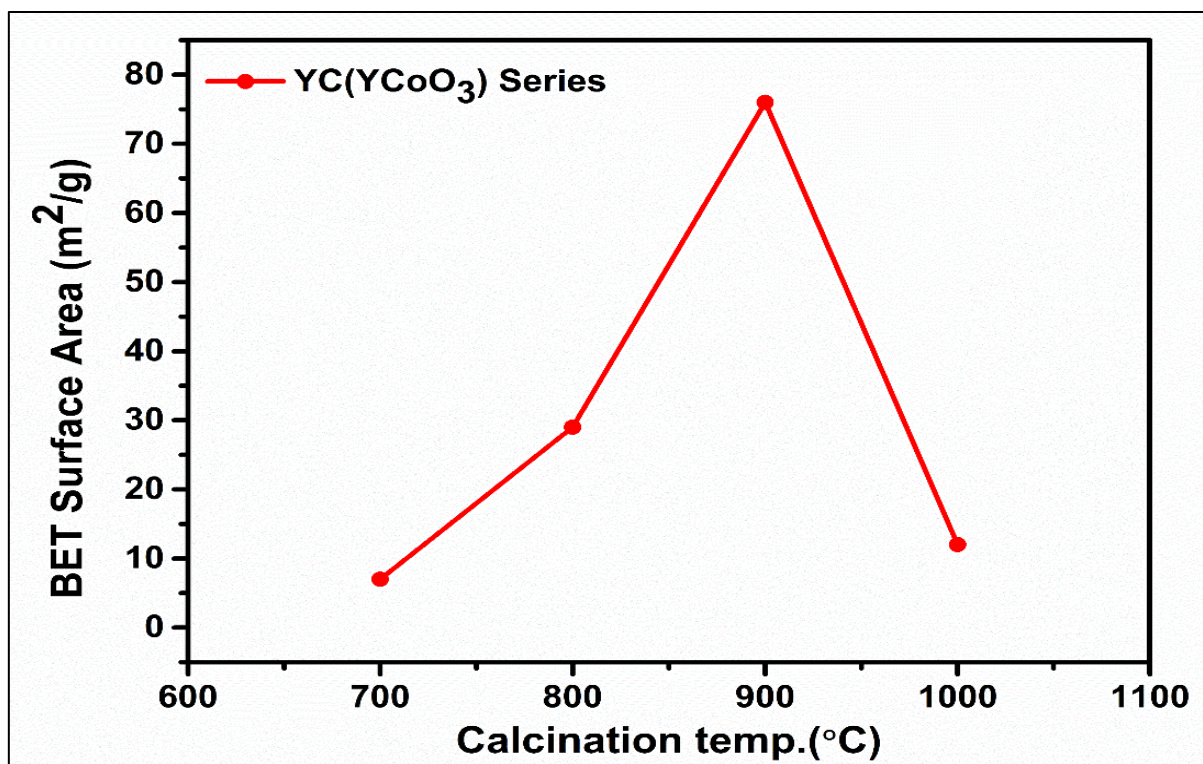


Fig 1 Graph Between BET Surface Area and Calcination Temperature (YC- Series).

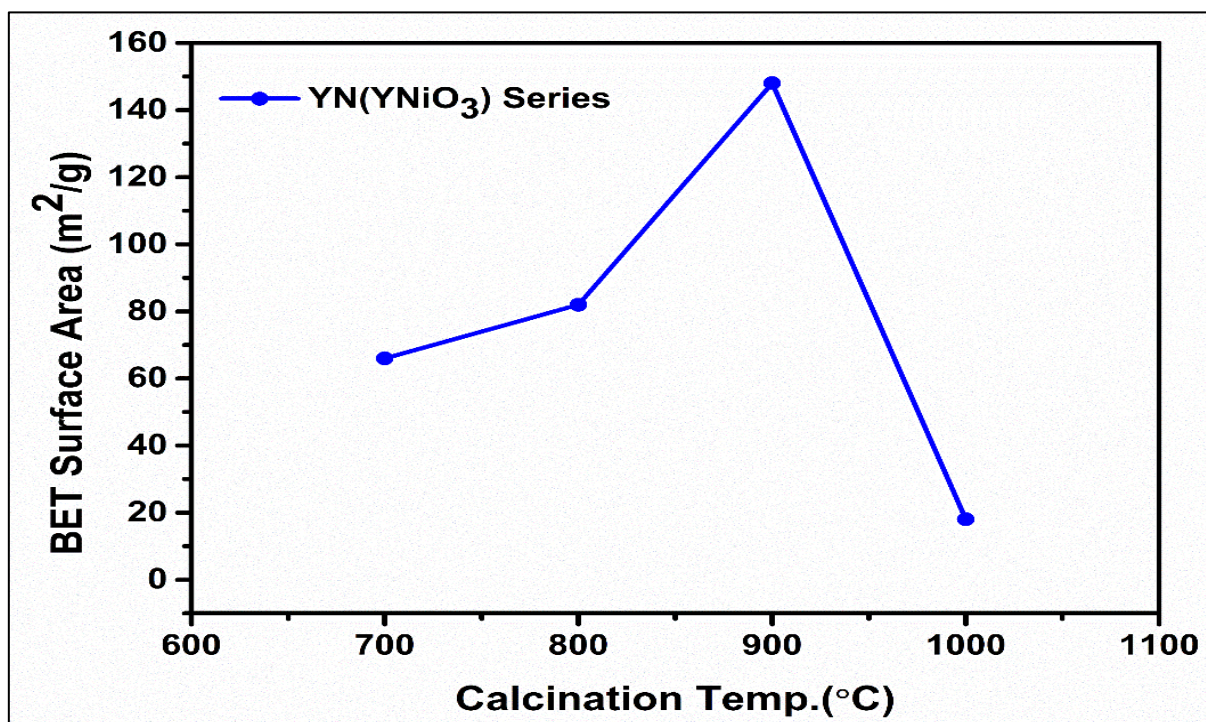


Fig 2 Graph Between Calcination Temperature and BET Surface Area (YN- Series).

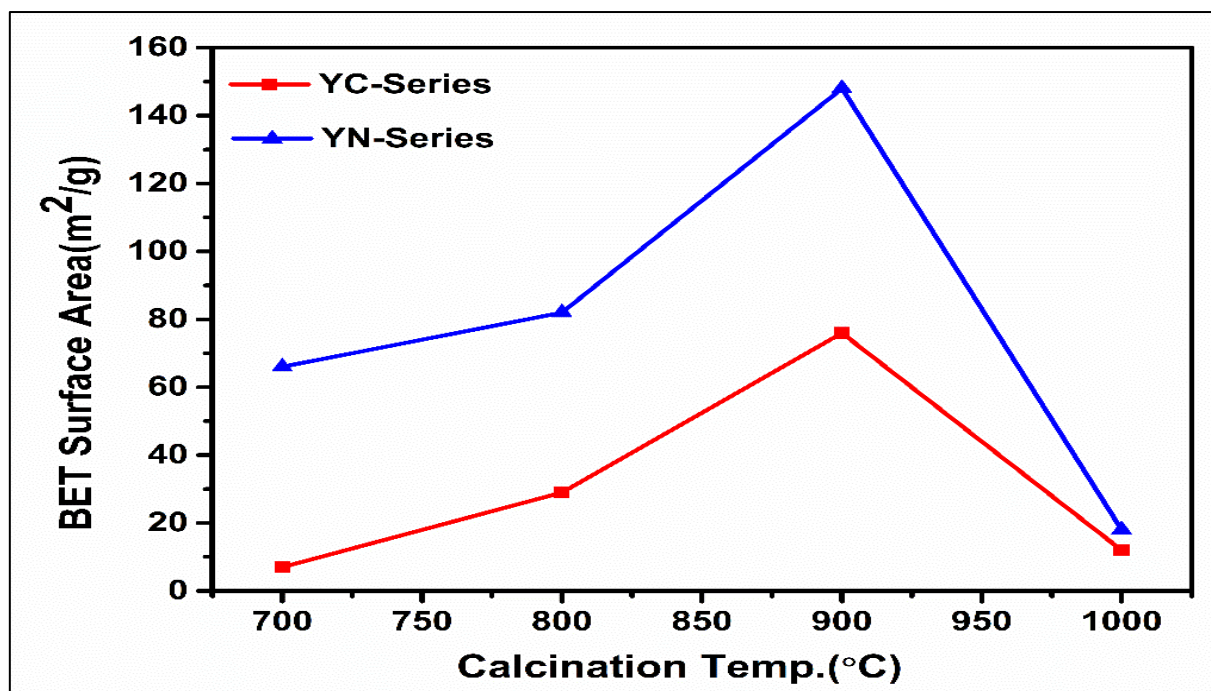


Fig 3 Graph Between BET Surface Area and Calcination Temperature (for YN and YC- Series).

IV. CONCLUSION

Thus, it is concluded that there is variation in BET Surface area with calcination temperature. And YN (YNiO₃) samples show higher values of surface area than YC(YCoO₃) samples.

➤ Funding Sources

The author(s) received no financial support for the research, authorship, and /or publication of this article.

➤ Conflict of Interest

The authors do not have any conflict of interest.

➤ Data Availability Statement

This statement does not apply to this article.

➤ Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

➤ *Informed Consent Statement*

This study did not involve any clinical trials.

➤ *Permission to Reproduce Material from Other Source*

- Not Applicable.

➤ *Author Contribution*

- Jyoti kumari: Methodology, data collection and observation, analysis, writing. (ORCID Id: 0009-0006-8603-6443) (Contact no. 9113755981)
- Rabindra Kumar: Conceptualization, methodology, supervision. (ORCID Id: 0000-0002-5821-8286) (Scopus Author's Id: 57201767800 and Contact no. 9431871996)
- Vijay Kumar: Contact -9155325413
- Sima Kumari: Review. (ORCID id: 0009-0006-6522-6408)

ACKNOWLEDGEMENT

Authors are thankful to the “Head, University Department of Chemistry, T.M. Bhagalpur University, Bhagalpur for providing laboratory facilities.

REFERENCES

- [1]. Kumar, R., et al. (1990). *Journal of the Indian Chemical Society*, 67, 508.
- [2]. Ye, X., Wang, X., et al. (2022). *Dalton Transactions*, 51, 1745–1753.
- [3]. R. M. N. (1986). [Doctoral dissertation, Bhagalpur University]. Bhagalpur University.
- [4]. Nicollet, C., & Tuller, H. L. (2022). *Chemistry of Materials*, 34, 991–997.
- [5]. Kumari, S., Kumar, B., Kumar, R., & Bhagat, S. (2004). Mixed metal oxides and catalysis. *Asian Journal of Chemistry*, 16(3–4), 1305–1310.
- [6]. Zeng, Z., et al. (2020). *Chemical Society Reviews*, 49, 1109–1143.
- [7]. Kumari, S., Kumari, B., Bishwas, B. L., & Kumar, R. (2006). Catalytic behaviour of mixed metal oxides of LnMO_4 for the thermal decomposition of carbamide. *Asian Journal of Chemistry*, 18(2), 1025–1031.
- [8]. Spedding, F. H., & Daane, A. H. (Eds.). (1978). *The rare earths* (p. 578). Iowa State University Press.
- [9]. Rao, T. S. R. P. (Ed.). (n.d.). *Advances in catalysis and technology* (p. 33). Wiley Eastern.
- [10]. Kumar, M., et al. (2020). *Journal of Emerging Technologies and Innovative Research*. 1063.
- [11]. Enger, B. C., Lodeng, R., & Holmen, A. (2009). Evaluation of reactor and catalyst performance in methane partial oxidation over modified nickel catalysts. *Applied Catalysis A: General*, 364(1–2), 15–26. <https://doi.org/10.1016/j.apcata.2009.05.033>
- [12]. Kumari, J., Kumar, R., Kumar, V., & Kumari, S. (2025). Studies on synthesis and physico-chemical properties of mixed oxide of rare earth transition metals of the type LnMO_3 . *Journal of Emerging Technologies and Innovative Research*, 12(11), 61–68. <https://doi.org/10.56975/jetir.v12i11.572396>