Layered architectures based on transition metals as efficient light harvesters for depollution reactions under sunlight irradiation

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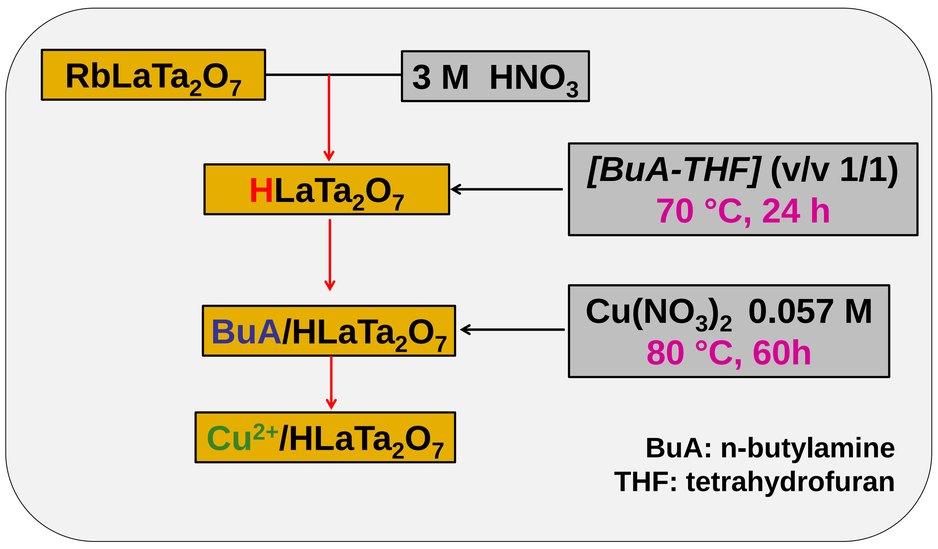
INTRODUCTION

Nowadays, efforts to develop novel light harvesters with high activity, stability and economy of precious metals it is fundamental in the field of photocatalysis.

In this regard, coupling the small band gap of *p*-type CuO with that of *n*-type active $HLaTa_2O_7$ protonated perovskite is expected to produce charge carriers with longer lifetime and beneficial impact on the photoactivity [1].

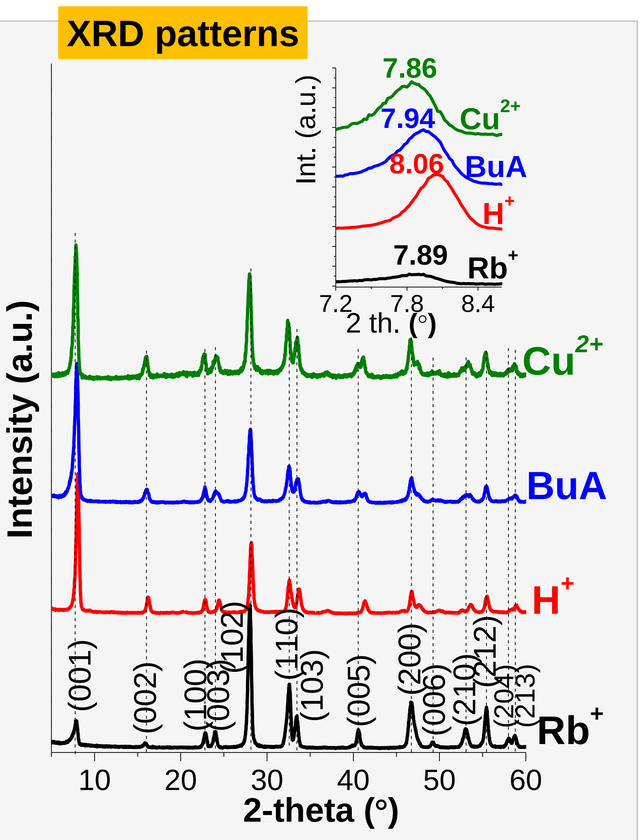
This study employs a facile route to fabricate $Cu^{2+}/HLaTa_2O_7$ layered architecture through the modification of $RbLaTa_2O_7$ via protonation-butylamine intercalation reactions. The catalytic performances of the synthesized layered materials have been investigated for the photodegradation of phenol under sunlight irradiation.

METHODS



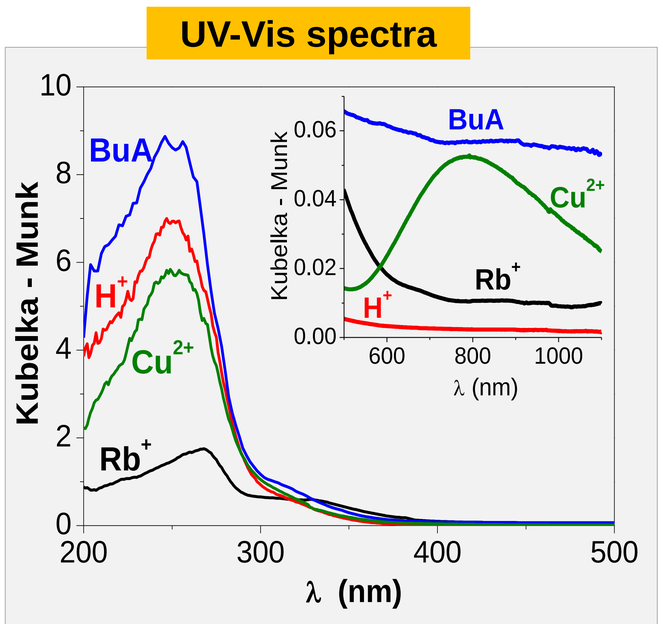
RESULTS

XRD patterns



(001) line diffraction changed after guest species hosted by interlayer of $RbLaTa_2O_7$

UV-Vis spectra



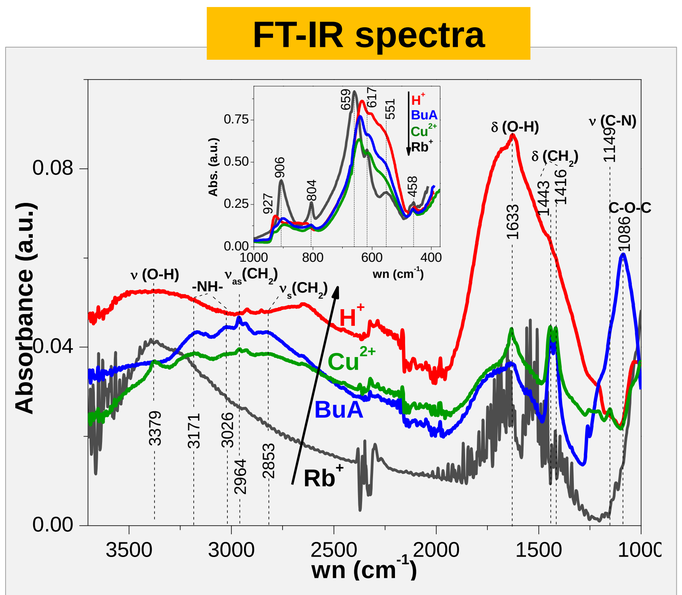
550-1000 nm → *d-d* transition of Cu^{2+} ion available for $Cu^{2+}/HLaTa_2O_7$ layered architecture

Photocatalyst	SSA (m^2/g)	Eg (eV)
$RbLaTa_2O_7$	1.5	3.78
$HLaTa_2O_7$	2.6	3.08
$BuA/HLaTa_2O_7$	3.2	3.03
$Cu^{2+}/HLaTa_2O_7$	4.1	3.10

After intercalation of guest molecules:

- enlargement of the specific surface area
- lower band gap values

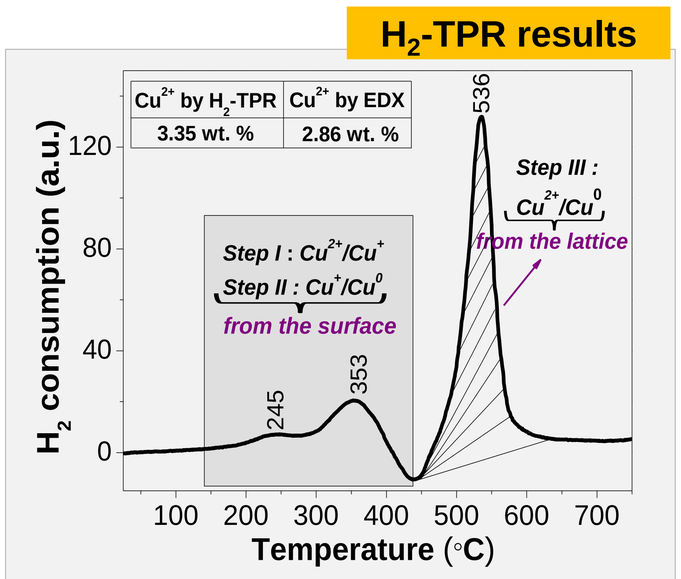
FT-IR spectra



Cu^{2+} introduction → $[Cu^{2+}\text{-}C_4H_9\text{-}NH_3^+]^+(LaTa_2O_7)$- complex is formed.

Below 1000 cm^{-1} → red shift of Ta-O octhaedra of $H^+/BuA/Cu^{2+}$ guest molecules

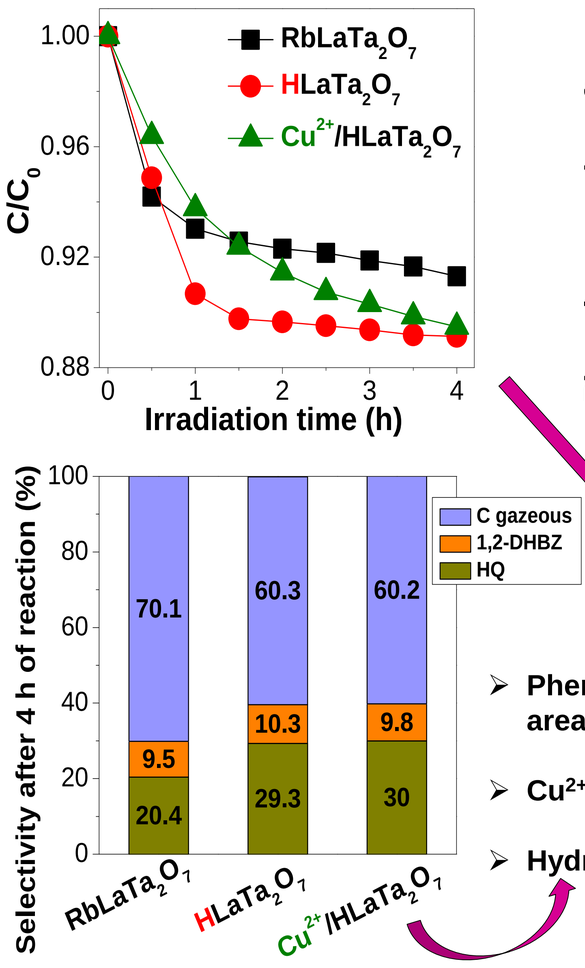
H_2-TPR results

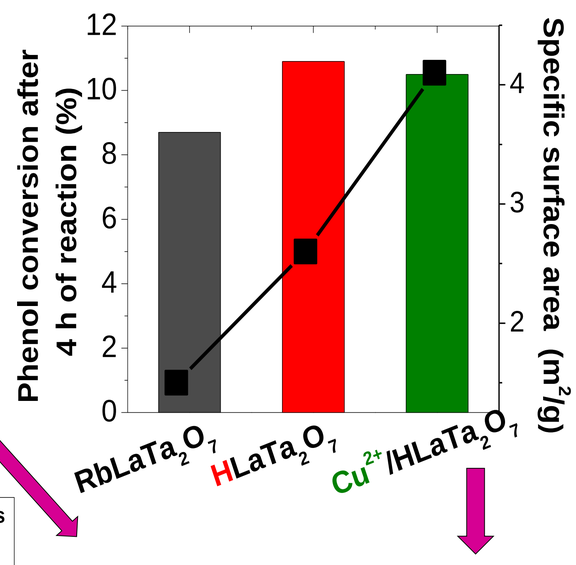


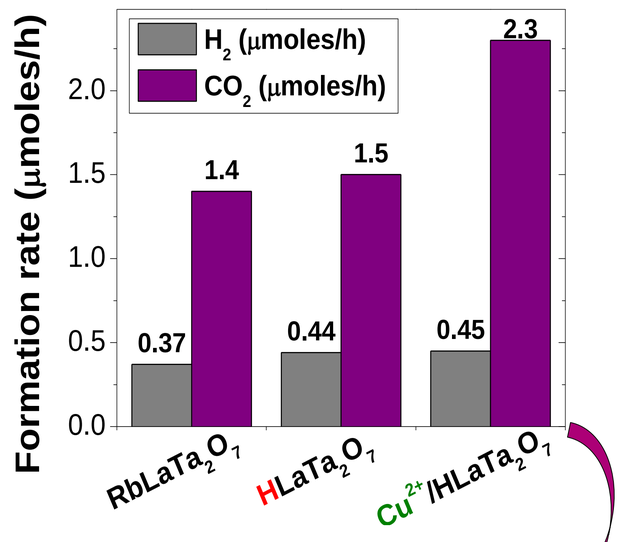
Co-existence of both Cu^{2+} on the surface as well as in between the galleries of $Cu^{2+}/HLaTa_2O_7$ modified layered perovskite.

Up to 25 % Cu^{2+} incorporated in between layers.

Photocatalytic degradation of phenol under sunlight irradiation







- Decrease of phenol concentration is improved when Rb^+ is replaced by H^+/Cu^{2+} in layered perovskite
- Phenol conversion increases with specific surface area but dependence on exposed surface area is not linear.
- $Cu^{2+}/HLaTa_2O_7$ composite → the most efficient photocatalyst in terms of CO_2 production rate
- Hydroquinone (HQ), and 1,2-dihydroxybenzene (1,2-DHBZ) → major intermediates

CONCLUSIONS

We have demonstrated the intercalation of Cu^{2+} in between the 2D galleries of $HLaTa_2O_7$ lamellar perovskite via intercalation of n-butyilamine spacer.

$Cu^{2+}/HLaTa_2O_7$ material exhibits enhanced photocatalytic activity in terms of CO_2 rate formation, under sunlight irradiation as compared to unmodified $RbLaTa_2O_7$. This behavior is attributed to the enlargement specific surface area, decreasing photogenerated e^-/h^+ pairs recombination rate and shrinkage of band gap.

Ongoing experiments show that the photocatalytic response can be further improved by calcination at various temperatures to create high density *p-n* heterojunction between copper species and $(LaTa_2O_7)^-$ layers.

Acknowledgements

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References

M.I. Hossain, F.H. Alharbi, N. Tabet, Sol. Energy 2015, 120, 370-380

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