

# Intelligent Materials such as Rare Earth Elements on High-Tech Materials Engineering for Catalysis and Environmental Applications

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## ABSTRACT

Substances engineering and catalysis are referred to as primary sciences, that could deeply contribute to the technological improvement of our nations and in addition to make sure the environmental protection and cleansing from each organic and inorganic contaminants. So, the era of the most desired chemical and fuels inclusive of (CH<sub>4</sub>) or to Carbon monoxide (CO/H<sub>2</sub>), Methanol (CH<sub>3</sub>OH) or maybe to Hydrogen (H<sub>2</sub>) and Ammonia (NH<sub>3</sub>) calls for strongly lively, selective, stable and in addition to reusable materials (catalysis) to meet the mankind desires. The willpower and removing each inorganic and organic are particularly appeared unique difficulty in healthcare. So that, a lot of these regions robust substances for the entire transformation of these chemical products. Indeed, zeolite materials are very explored inside the current years as they present advanced houses in both catalysis and environmental worries. Also, its aggregate with transition noble and non-noble metals also are considered in an effort to improve the catalytic yields. In truth, here, it's far ascribed the function of transition uncommon-earth (RE) factors inside the hybrid substances engineering for advanced technological applications. It established that uncommon earth oxides may enhance catalytic functions and keep away from the loss of acid sites under the Fluid Catalytic Cracking (FCC) unit operation. Moreover, it is proven that (RE) factors might be used for substances engineering for high-tech uses which include in Hydrogen Evolution Reaction (HER), Methanol Oxidation Response (MOR), Oxygen Evolution Reaction (OER) and Oxygen Discount Response (ORR). Many different reactions may be realized over hybrid substances made *via* the usage of Rare Earth (RE) factors with stepped forward catalytic performances. Therefore, because of the huge homes of transition Rare-Earth (RE) metals, more feasible incredible materials can be engineered in upcoming generation.

**Keywords:** Rare-earth-modified-materials; Catalysis; Environments; Zeolites; Engineering; Technologies

## INTRODUCTION

Materials engineering and catalysis are referred to as primary sciences, that may deeply make contributions to the technological development of our international locations and as well as make certain the environmental safety and cleansing from each organic and inorganic contaminants. So, the layout and synthesis of powerfully performance materials are required for plenty technologies, consisting of in conversion of higher hydrocarbons to decrease hydrocarbon as Methane (CH<sub>4</sub>) or to Carbon monoxide (CO/CO<sub>2</sub>), Methanol (CH<sub>3</sub>OH) or even to Hydrogen (H<sub>2</sub>) [1,2]. Also, overall performance hybrid

substances also are so wanted for recycling waste products such innocent (CO<sub>2</sub>) and dangerous (CO/NO<sub>x</sub>) to fee-brought merchandise, because it have to be considered as an alternative fuels, which restriction the use of feedstock fuels from herbal fuel reforming or better hydrocarbons cracking [3,4]. Hybrid materials embellishments and characterizations permit additionally the detection and quantification of organic compound in our food merchandise, to restrict our exposure in some sicknesses along with most cancers, diabetes and so fourth [5,6]. In truth, in the past few many years, many engineering routes were suggested and and thoroughly mentioned so that it will find exceptional substances for substantial technological

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applications. So that, those methods include: The exploration of metal oxides substances such alumina, ceria, silica, manganese oxides [7], they can be used as a matrix of metallic nanoparticles or as an active catalyst. The improvement and characterization of many sorts of carbons including nanotubes, nanofibers, polymers, heteroatoms integrated carbons, black carbons and so forth, have critically mentioned to boost the performance of composite materials. The use of fee-effective metals together with transition cobalt, zinc, nickel, copper, molybdenum hybrid substances and so fourth had been notably considered in each catalysis and environmental technologies. Porous substances, inclusive of wise as zeolite materials lately are completely regarded as powerfully energetic catalysts in a extensive range of catalysis technology. certainly, as explained in Zhang-a's work, It overlaying a deep range of pore sizes beginning from micropores ( $D < 2$  nm), mesopores ( $2 < D < 50$  nm) to macropores ( $D > 50$  nm), so zeolite substances are versatile and crucial in packages including gas separators, ion exchangers generation, catalysts, for electricity retaining, in sensor and beyond. Additionally, using zeolites on multicomponent reactions is introduced in Lima's work. So, it's miles notified that an expanded materials features together with efficiency, catalytic selectivity and pastime, along with their useful environmental benign, elaboration routes and material reusability, it receives so awesome the union of heterogeneous catalysis and MCRs famous an open framework of opportunities. Furthermore, Wang's file showed the synthesis and makes use of of center-shell, hole, yolk-shell multifunctional architecture zeolites substances. In truth, the authors deeply discussed the brand new layout techniques for massive zeolite related and highly priced affiliated with their education and the need for deeper research into their uses show off sizeable challenges. Another crucial elegance of substances is also added due to their advanced homes including magnetic (neodymium), lights (lanthanum), catalytic at excessive temperature (cerium/lanthanum), element of a amazing form of glass (praseodymium), visible shows in devices (Yttrium, terbium, europium) and (gadolinium) is used in MRI and X-ray scanning technique and in addition to television screens. Further, as proven here, this elegance of elements named as rare earth materials may possess superior features which would be exploitable for destiny catalysis/technological composite materials engineering. Consequently, on this review article one consciousness is dedicated to the novel improvement and application of hybrid substances fabricated from uncommon earth in union with different materials.

## LITERATURE REVIEW

### New insights on the use of rare earth elements on advanced materials engineering for catalysis and environmental technologies

So, in a assessment mounted by Akah A, it's far defined that rare earth oxides might enhance catalytic features and avoid the loss of acid websites under the Fluid Catalytic Cracking (FCC) unit operation, specially when heavy residue with higher metallic content is used as feed. Indeed, this evaluate suggests the consequences of rare earth substances on the structure,

balance and in addition to hobby of FCC catalysts. Additionally, other appears of uncommon earth metals was taken inside this article. Moreover, in 2019, a evaluation mentioned on using rare earth elements with transition metallic-based totally substances for catalysts layout, synthesis and applications have been exhaustively analyzed in Gao's studies work. It indicates that these rare earth metals could be used for substances engineering for high-tech applications as Hydrogen Evolution Response (HER), Methanol Oxidation Reaction (MOR), Oxygen Evolution Response (OER) and Oxygen Reduction Reaction (ORR). Many blessings and challenges of hybrid substances made through using uncommon earth elements are considered within the examine. An Alumina ( $\text{Al}_2\text{O}_3$ ) supported Nickel catalysts ( $\text{Ni}/\text{Al}_2\text{O}_3$ ) modified with the aid of uncommon earth factors turned into established as a fairly lively catalyst for the decomposition of  $\text{NH}_3$  as defined in Okura's paper. Evaluation outcomes displays that the Lanthanum (La) changed catalysts reaches the best ammonia conversion. To reinforce the catalytic performance of this modified  $\text{Ni}/\text{Al}_2\text{O}_3$  catalyst a pretreatment step became required. Subsequently,  $400^\circ\text{C}$  and  $600^\circ\text{C}$  as calcination and reduction temperature respectively indicates the very best  $\text{NH}_3$  conversion as high as ninety four % at  $550^\circ\text{C}$ . Furthermore, it is notified from Li's work that lanthanum is the fine choice for enhancing the nickel dispersion and the ratio of steel to acid capabilities among uncommon earth factors. Indeed, due to this fact, high catalytic hobby and isomerization selectivity became reached while this (Los Angeles) modified  $\text{Ni}/\text{HY}$  is used.

Even as other rare earth modified nickel catalysts suggests bad catalytic overall performance because of the discount of acidity characteristic and Ni dispersion, simplest a lower ratio of meta to acid functions displayed. In 2019, a  $\text{FeK}/\text{Al}_2\text{O}_3$  and rare earth factors as (Los Angeles, Ce and Y) were combined to assemble a  $\text{FeK}/\text{M}-\text{Al}_2\text{O}_3$  catalysts for direct  $\text{CO}_2$  hydrogenation to liquid hydrocarbons as shown with the aid of Zhang's team. So, the incorporation of M (l. a., Ce and Y) become observed to boost the selectivity of  $\text{C}_{5+}$  hydrocarbon formation and decrease the selectivity for  $\text{CH}_4$  technology. Hence, at above 20% of Carbon Dioxide ( $\text{CO}_2$ ) conversion,  $\text{C}_{5+}$  selectivity will be decorate about 60% with around 11%  $\text{CH}_4$  selectivity. In particular, it discovers that the addition of rare earth element on the catalysts minify the  $\text{H}_2$  adsorption and assist the adsorbed  $\text{CO}_2$  species, consequently, leading to reinforce the liquid hydrocarbons ( $\text{C}_{5+}$ ) selectivity over to fuel hydrocarbons. Furthermore, 3 rare earth based composite materials (La, Ce and Y) zeolite performances had been as compared by means of Lemos' institution in terms of acidity function and catalytic residences. Indeed, it discovers that LaHY possesses the strongest bronsted acid web sites than those of important HY and CeHY. So, it proved that LaHY catalyst present the high quality interest for n-heptane cracking with very low coke era. Hence, it indicates that the exchange of HY *via*  $\text{Ce}_{3+}$  or  $\text{La}_{3+}$  boosted the thermal balance, which in all likelihood due to the formation of strong oxygen complexes between lattice oxygen atoms and rare-earth cations. The thermal balance turned into extra marked with  $\text{La}_{3+}$  as compared to  $\text{Ce}_{3+}$ . In addition, Du X, et al., examined 3 uncommon-earth oxides specifically ( $\text{La}_2\text{O}_3$ ,  $\text{CeO}_2$  and  $\text{LaPO}_4$ ) for the properties development

of the USY zeolite catalyst as vanadium traps. In reality, it located that uncommon-earth oxides is very well distributed on the zeolites surfaces and a number of uncommon-earth ions moved to cages of the zeolites beneath calcination and hydrothermal procedure. Therefore, the catalytic pastime and as well as hydrothermal balance of the changed zeolites had been boosted. While in  $\text{LaPO}_4$ -USY zeolite,  $\text{LaPO}_4$  was handiest disbursed at the zeolite surface and did no longer effect the properties of catalyst. So that it will upward thrust light olefins yield and selectivity under catalytic cracking of propane one approach was used by Pouria R, et al., to introduce (la) on ZSM-5 zeolite catalyst through wet impregnation observed by way of calcination step. Certainly, analysis consequences suggests that because the temperature multiplied, the variety of bronsted acid sites reduces and which therefore accentuate light olefins technology in addition to catalyst balance. Especially, the l. a.-ZSM-5 handled beneath ( $\text{N}_2$ ) atmosphere changed into largely solid than l.a. -ZSM-5 calcined beneath air flow. A los angeles/SAPO-eleven catalyst changed into layout and synthesized by using Liu's group through one-pot approach. It discovers that la ions raise the depolymerization of phosphorus species and interaction with aluminum and phosphorus species. It determined that the presence each silicon and l.a. ions, does no longer allow Los Angeles ions to incorporate into zeolite framework. Then,  $\text{LaPO}_4$  conserves framework shape beneath steam attack. Particularly, it notified that  $(\text{La}(\text{OH})_2)^+$  ions compensate structure tensions and improve the bond electricity of Al-O inhibiting the desilication reaction under thermal handling. Therefore, l. a./SAPO-eleven elevated isomerization response (about 95% beautify of iso-paraffin) and inhibit cracking. Du's institution investigated ions location and migration in l.a.-exchanged NaY zeolite, *via* calcination of  $\text{LaNH}_4\text{Y}$ , LaY is ready. So, analysis insights indicates that Los Angeles cations to begin with are placed in supercages and their hydration covering are stripped off and they circulate to small SI'positions of sodalite cages beneath heating and dehydration. Consequently, it's miles stated that rare-earth species secure the hydrothermal balance of the zeolite to strength the acid website online density and catalytic functions. Wang X, et al., hooked up a consistency overview on rare earth hybrid materials engineering for in addition technological packages such electro catalysis. Each improvement and blessings of uncommon-earth substances mentioned, future research methods addressed to help scientist for rapid technological development. So, it is highlighted from Liu, P., et al., paintings that Rare Earth (RE)-exchanged zeolite-Y is the essential active constituent of Fluid Catalytic Cracking (FCC) catalysts. In this experience, a sequence of Yttrium ( $\text{Y}^{3+}$ ) exchanged zeolite-Y changed into elaborated and characterized with the aid of physicochemical methods. As lanthanum ( $\text{La}_{3+}$ ) exchanged zeolite-Y,  $\text{Y}^{3+}$  cations had been specifically located internal sodalite units near the double six-membered rings. It's miles notified that the trade of  $\text{Y}^{3+}$  cations by way of  $\text{Na}^+$  reasons a noticeable lower of the unit mobile due to the comparatively small ionic radius and excessive rate density of  $\text{Y}^{3+}$  cations. subsequently,  $\text{Y}^{3+}$ -exchanged HY-primarily based FCC catalyst exhibited higher steam balance, superior selectivity for high price products inclusive of ( $\text{C}_5+$  fuel and liquefied petroleum gasoline) underneath n-docosane cracking compared with  $\text{La}^{3+}$  exchanged HY-based totally catalysts. Through liquid section ion exchanged,

a series of CeY zeolites were designed and synthesized by Zu, Y., et al., group. The fabricated materials confirmed adsorptive and energetic species web sites in CeY zeolite toward ultra-deep desulfurization in a set-mattress column and as properly version fuels. It's miles advised that this course should play an instructive role for the improvement of the directive layout of effective adsorption energetic web sites for superior desulfurization adsorbents. Greater lately, the research of  $\text{LaNi}_5$ -type alloy electro catalysts have been mentioned in Tamura's work for  $\text{H}_2$  evolution response. It is tested that the synthesized catalysts ( $\text{LaNi}_5$ -kind alloy) displayed high catalytic in comparison with the constituent metals and their activities have been almost competitive with the ones of Pt and Pd catalysts. The manage of temperature and modern density, avoid the catalysts ( $\text{LaNi}_5$ -type alloy) floor alteration. furthermore, a intended cost-effective catalyst ( $\text{Pt}_{1.5}\text{La}_{1.5}\text{Ni}_{12}/\text{NPC}$ ) became said through Zheng, L, et al's crew for the hydrogen technology *via* Hydrogen Evolution Reaction (HER) in alkaline media (1.zero M KOH). Certainly, because of the synergistic effect between element as Pt, la, Ni and as well as nanocarbon help, the designed ( $\text{Pt}_{1.5}\text{La}_{1.5}\text{Ni}_{12}/\text{NPC}$ ) displays maximum catalytic performances for the HER which outperforms all the considered cloth catalysts in this observe and even industrial Pt/C catalyst.

## DISCUSSION

It desires ultralow over potential of 20 mV and 132 mV to obtain 10 and 100 mA under the HER respectively. In 2020, it's miles said from Zou HH, et al's paintings a photoelectrochemical (%) water splitting under the movement of novel LTO/ $\text{LaOCl}@N\text{-C}$  Microspheres Heterostructures (MH) for hydrogen generation. The maintain hybrid photocatalyst LTO/ $\text{LaOCl}@N\text{-C}$  (MH) exhibited excellent %hydrogen evolution function and in addition to better durability while as compared to the pure LTO fabric. So, at 0.7 V *vs.* RHE, underneath simulated solar irradiation, the designed photocatalyst shows higher overall performance of photocatalytic hydrogen evolution rate, which turned into as excessive as  $26.43 \mu\text{mol}/\text{h}\cdot\text{cm}$ . consequently, it's far mentioned that LTO/ $\text{LaOCl}@N\text{-C}$  (MH) photocatalyst surpasses many formerly recommended materials based totally on LTO composite catalysts. Recently Ye X, et al., cautioned a bifunctional metastable  $\text{LaOCl}@h\text{cp-Ni}$  nanocomposite photocatalyst and photocatalytic sports *via* Schottky impact engineering for environmental remediation and electrocatalysis packages. So, it's miles notion that this cloth ( $\text{LaOCl}@h\text{cp-Ni}$ ) might be a potential uncommon-earth primarily based Schottky catalyst for each photoelectrocatalytic oxygen evolution and as well as photocatalytic degradation of organic pollutants. In addition, in 2022, Gogoi's crew suggested a  $\text{BiOCl-LaOCl-1}$  composite catalyst for organic compound removal such Rhodamine B in aqueous media. So, beneath sunlight, the proposed catalyst ( $\text{BiOCl-LaOCl-1}$ ) delivers the very best catalytic interest of Rhodamine removal, hence permitting it to outperform all of the considered catalyst substances within the have a look at, consisting of  $\text{BiOCl}$  and  $\text{LaOCl}$  semiconductors. A N-regulated lanthanum phosphate ( $\text{N-LaPO}_4/\text{C}$ ) changed into followed by means of Zhao's group as a model catalyst for alkaline Oxygen Reduction Response (ORR), as it's miles an

crucial electrochemical energy conversion devices. Indeed, it's miles experimentally confirmed that the N-LaPO<sub>4</sub>/C reveals advanced ORR hobby and stability, which outperforms the commercial Pt/C catalyst. So, the N-doped LaPO<sub>4</sub> in the N-LaPO<sub>4</sub>/C is identified to be the active sites and the N law characteristic on lanthanum is believed to make sure enhance the catalytic pastime of N-LaPO<sub>4</sub>/C beneath the ORR. Also, it is furnished that N-LaPO<sub>4</sub>/C plus Ru<sub>2</sub>O demonstrated higher strength density and as well as lengthy existence cycle, which shall we to signify these materials as potential candidate in rechargeable Zn-air batteries as an air cathode. Furthermore, Liu C, et al., constructed a bifunctional LaN<sub>x</sub>C<sub>4-x</sub>-doped graphene in acidic-alkaline all-powerful electrocatalyst for oxygen electrode response. Indeed, the developed fabric (LaN<sub>x</sub>C<sub>4-x</sub>-Gra) with the correct composition of LaN<sub>2</sub>C<sub>2</sub>hex-Gra reveals capacity bifunctional overall performance with the unique Oxygen Evolution Response (OER) and Oxygen Discount Response (ORR) overpotentials of 0.68 V and 0.56 V respectively accompanied through OH ligands modification. consequently, as fully shown here materials engineering of superior hybrid substances *via* using Rare-Earth (RE) substances such Lanthanum (La), Cerium (Ce), Yttrium (Y), Neodymium, Samarium, Europium and so fourth should be considered to design and synthesized powerfully energetic composite substances for excessive tech applications along with environmental, catalysis, electrochemical sensors, biosensors, water managements, past technologies. Uncommon-earth (RE) may be tremendously taken into consideration as platinum group metallic-based materials isn't always cost-powerful than (RE).

## CONCLUSION

Cloth technology associated regions are referred to as key, that may deeply make contributions to the technological evolution, that may control the environmental pollutants from both natural and inorganic harmful products. Indeed, so one can fulfill these wishes, powerfully hybrid substances with cost-effectiveness are fully desired for excessive-tech packages. In order that, attributable to this pastimes, severa zeolite substances in current years were completely evolved and characterised and it discovered that they exhibit advanced functions in catalysis and environmental worries. Furthermore, its combination with transition noble and non-noble metals also are fully depicted to enhance the catalytic yields of the designed substances. Right

here, it's far shown that transition Rare-Earth (RE) factors might be adopted within the hybrid substances engineering for advanced technological programs. As uncommon earth oxides might beautify catalytic capabilities and keep away from the lack of acid websites beneath the Fluid Catalytic Craking (FCC) unit operation. Furthermore, it is shown that (RE) factors including lanthanum (La<sup>3+</sup>), (Ce<sup>3+</sup>), (Y<sup>3+</sup>), and so on might be used for substances engineering for high tech utilizations which includes in Hydrogen Evolution Reaction (HER), Methanol Oxidation Response (MOR), Oxygen Evolution Reaction (OER) and Oxygen Reduction Reaction (ORR), organic/inorganic pollution elimination. Different reactions can be realized over rare earth based catalysts with more suitable catalytic capabilities. Subsequently, due to the state of the art homes of transition uncommon-earth (RE) metals, greater feasible incredible substances will be designed in upcoming time frame.

## CONFLICT OF INTEREST

The author declares that this review article on rare earth modified materials was led in the absence of any profitable or marketable relationships that could be interpreted as a possible conflict of interest.

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