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Pt supported on CeTi-modified hexagonal mesoporous silica as photocatalysts for degradation of phenols in water

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Outline of the talk

- **Introduction**
- **Synthesis of the materials**
- **Characterisation of the materials**
- **Photocatalytic activity in the degradation of organic compounds from water**

Introduction

- Phenolic compounds → most toxic
  → carcinogenic
  → mutagenic pollutants

- Dispersion of TiO_2 on a support with high surface area ions can increase photocatalytic performances due to extended light absorption range and a better charge separation.

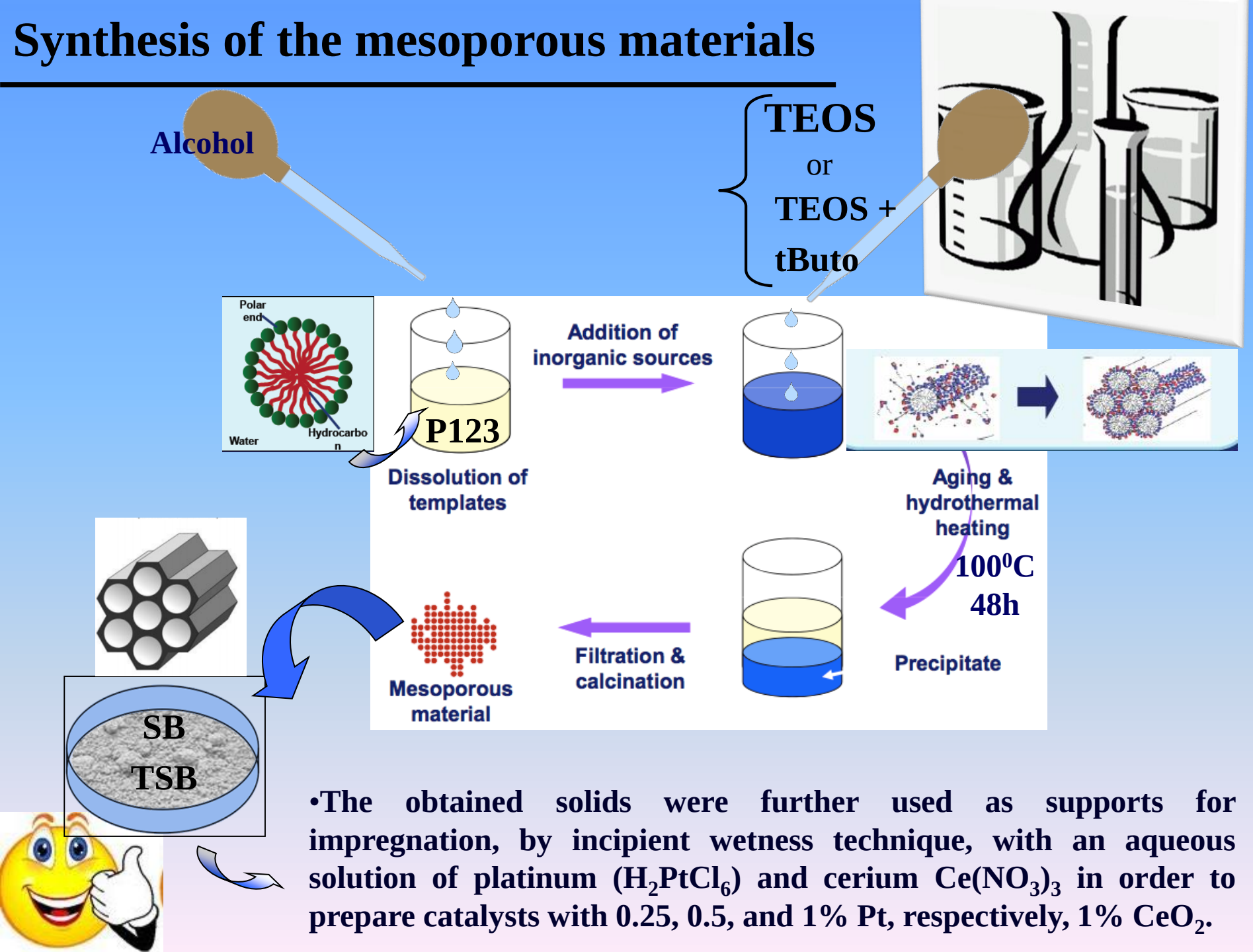
- Cerium is an interesting candidate to TiO_2 doping due to the same valence in the stable oxide and having four valence electrons both.

- The thermal and mechanical stability of Ce/TiO_2 photocatalysts was not good enough for practical applications.

- In order to address these problems, one approach is to disperse TiO_2 on the high surface area supports such as mesoporous silica and dopped it with different metals (e.g. Pt, Ce).

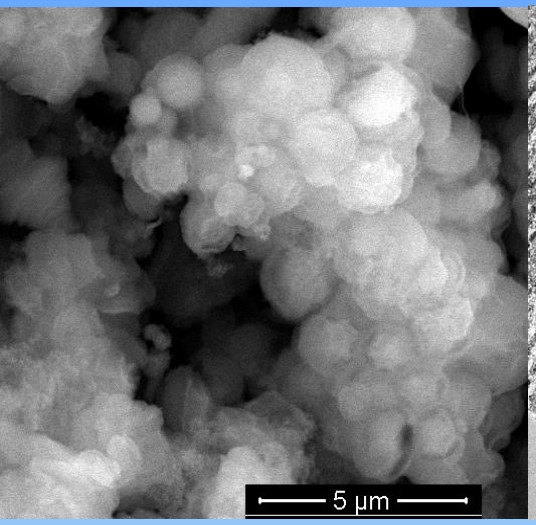
- Photocatalytic degradation of phenol and substituted phenols in wastewater has been widely investigated, the most used process being based on TiO_2/UV.

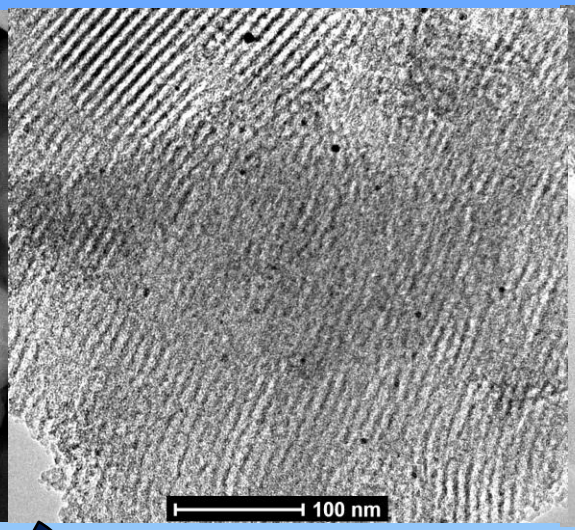
Synthesis of the mesoporous materials

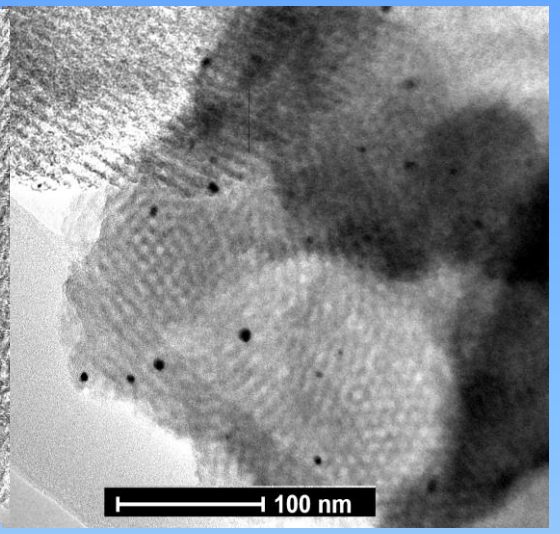


•The obtained solids were further used as supports for impregnation, by incipient wetness technique, with an aqueous solution of platinum (H_2PtCl_6) and cerium $Ce(NO_3)_3$ in order to prepare catalysts with 0.25, 0.5, and 1% Pt, respectively, 1% CeO_2.

Morphology and structure of the catalysts



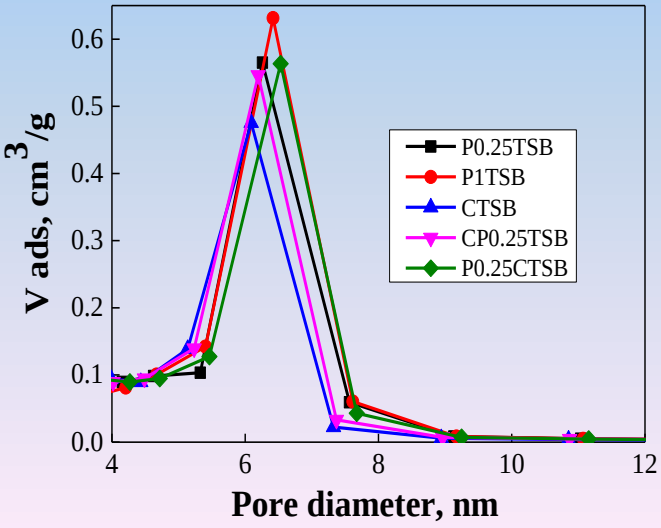


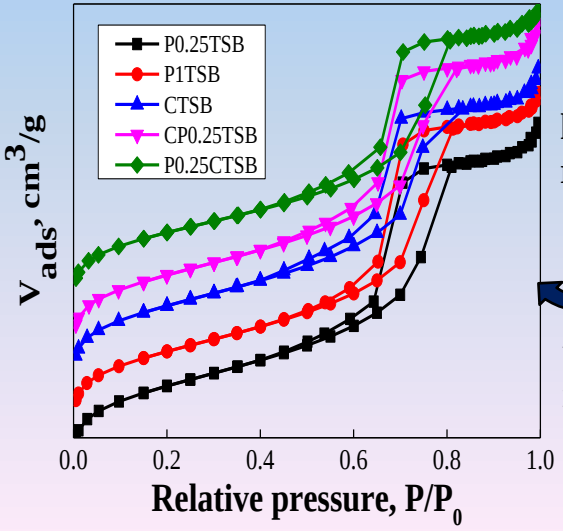


P0.25CeTi5-SBA-15 **P0.5CeTi5-SBA-15**

hexagonal channels with uniform pore size

N_2 adsorption-desorption isotherms and pore size distribution

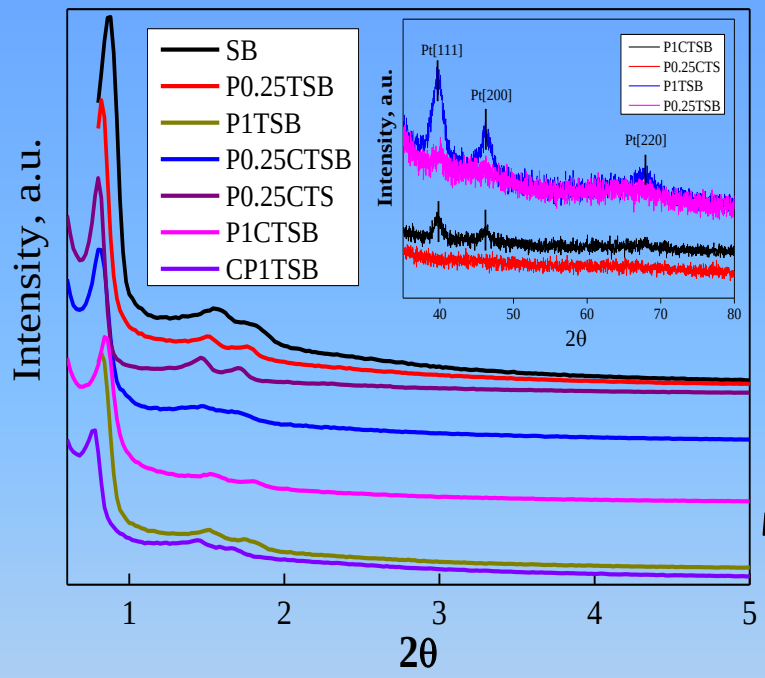




hysteresis loops close at a lower relative pressure

the nanoparticles are in the internal channels

Structure of the catalyst components

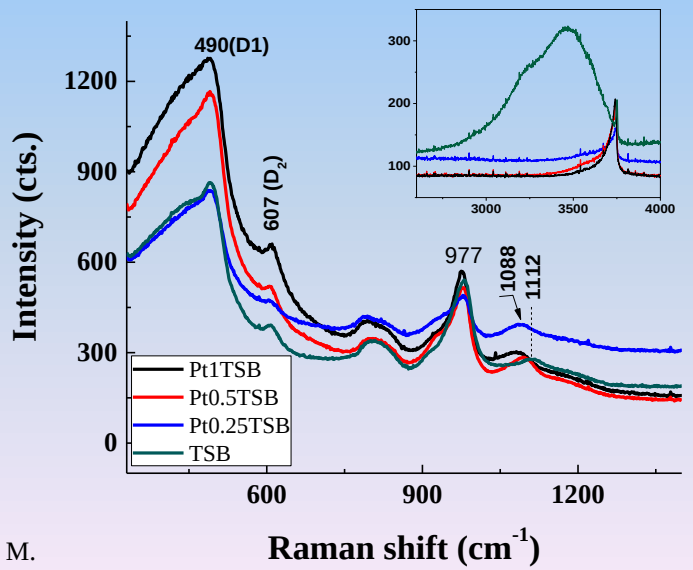


particle size is below the detection threshold (≤3 nm)

Pt has small particle size !!!
Very good dispersion !!!

Effect of composition and synthesis condition on ordered porous structure and crystalline phase of the samples with 5% TiO_2

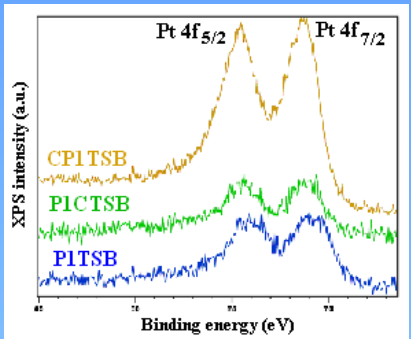
framework titanium present in the materials



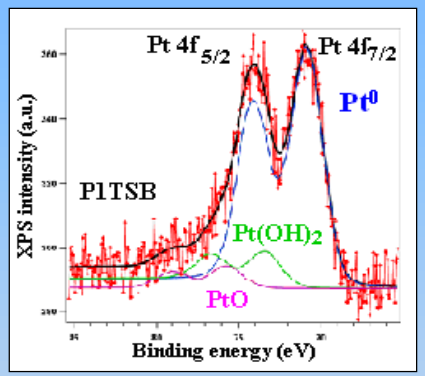
only a minor phase of extra-framework rutile in the P1TSB sample

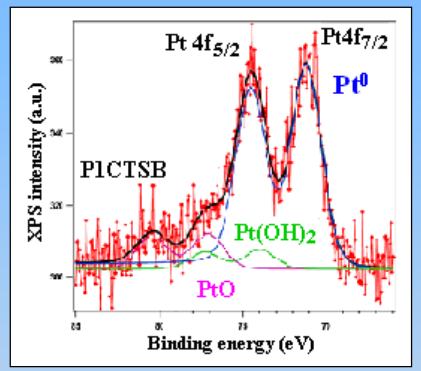
M. Ciobanu, G. Petcu, E.M. Anghel, F. Papa, N.G.Apostol, D.C. Culita, I. Atkinson, S. Todorova, M. Shopska, A. Naydenov, R. Velinova, V. Parvulescu, Applied Catalysis A: General, 2021, 619, 118123

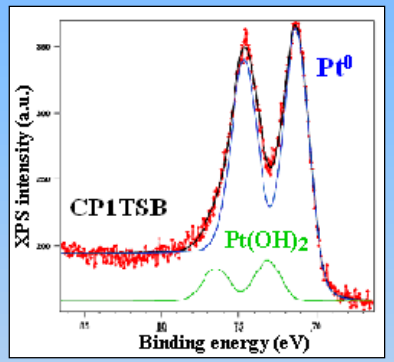
Surface composition

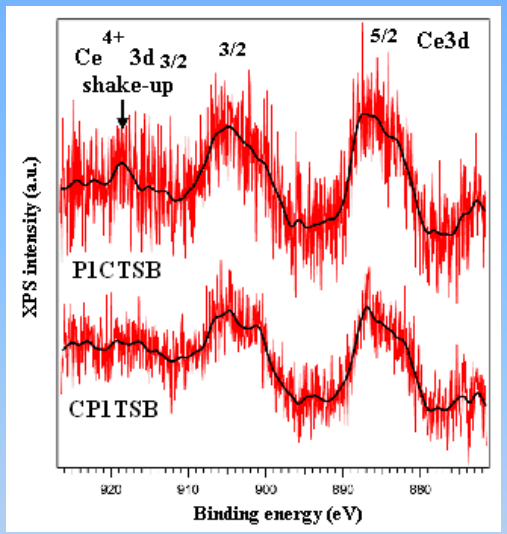


XPS spectra of Pt and Ce modified mesoporous silica









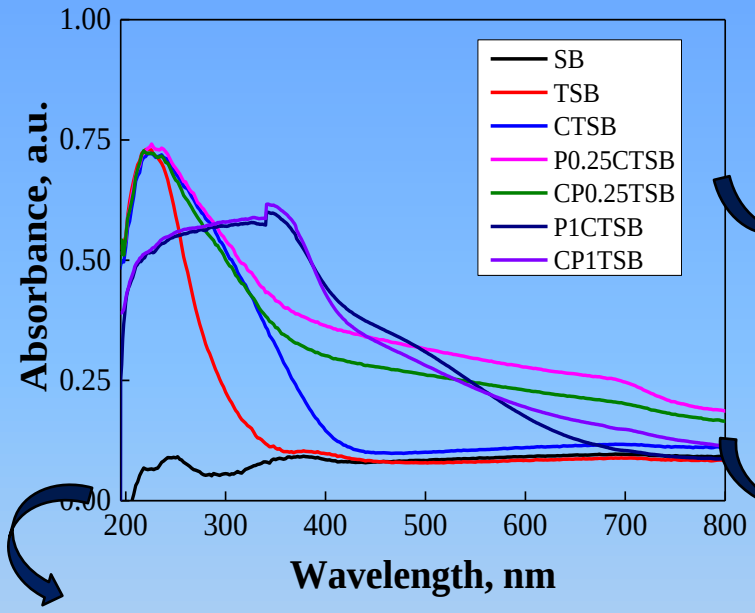
Pt species

71 eV Pt^0
73-74 eV $Pt(OH)_2$
75-76 eV PtO

The percentage of Pt and Ti species on the catalyst surface

Catalyst	Pt atomic species %			Ti atomic species%	
	Pt^0	PtO	$Pt(OH)_2$	TiO_2	TiOx
P1TSB	81.0	7.6	11.4	28.1	71.9
P1CTSB	72.8	12.4	14.8	33.2	66.8
CP1TSB	86.3	-	13.7	42.8	57.2

Optical properties



the strong peak at 230 nm indicates the pre
of the framework titanium species

the broad absorption band for samples with CeO_2 can be attributed to $O^{2-} \rightarrow Ce^{4+}$ charge transfer (277 nm) and to inter-band transitions (347 nm)

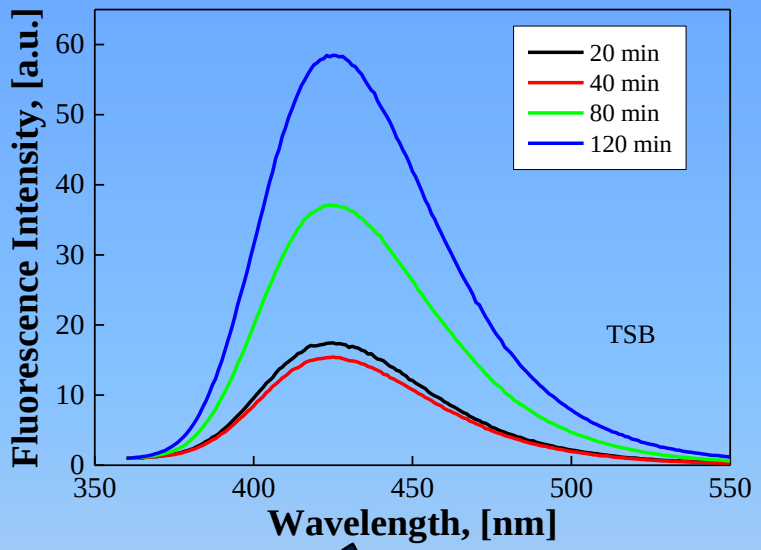
significant effect on adsorption can be observed for samples with 1% Pt which can be attributed to the remarkable effect of Pt under its strong interaction with titanium and cerium oxides dispersed on the support

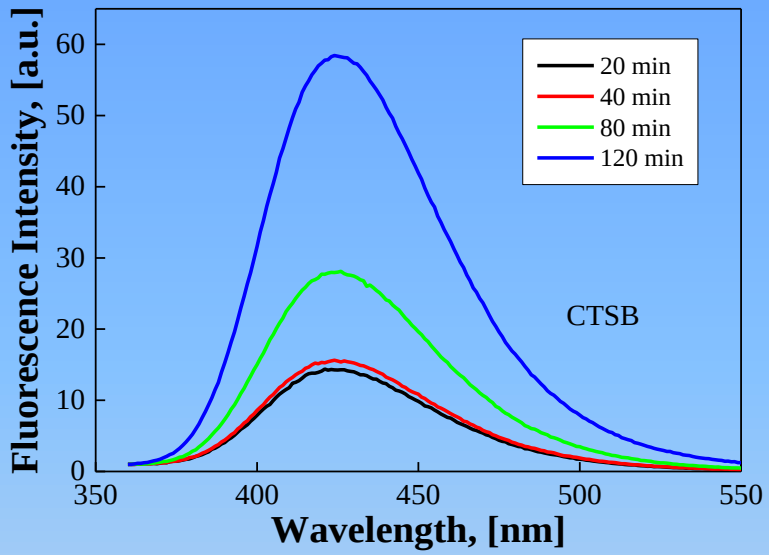
we have a high interface and stronger interaction between ceria and titania

Band gap values

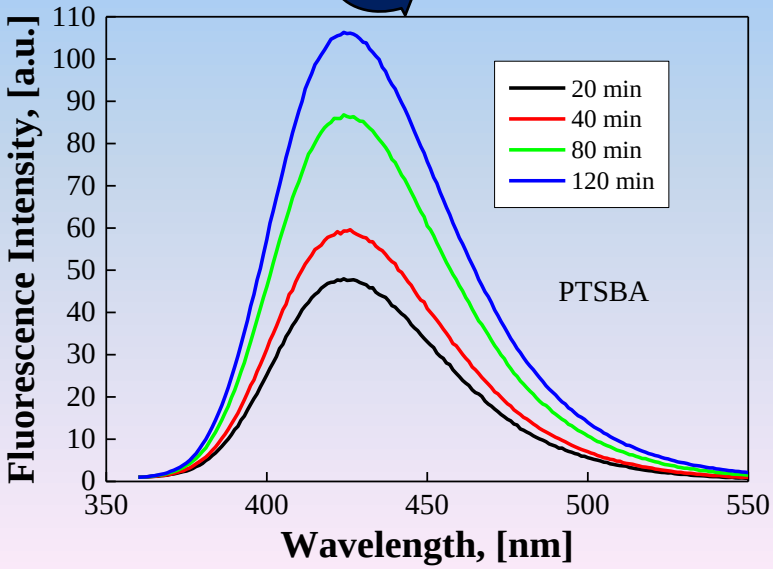
SB	TSB	CTSB	PTSB	CPTSB	PCTSB
3.95	3.87	2.71	3.22	2.46	2.31

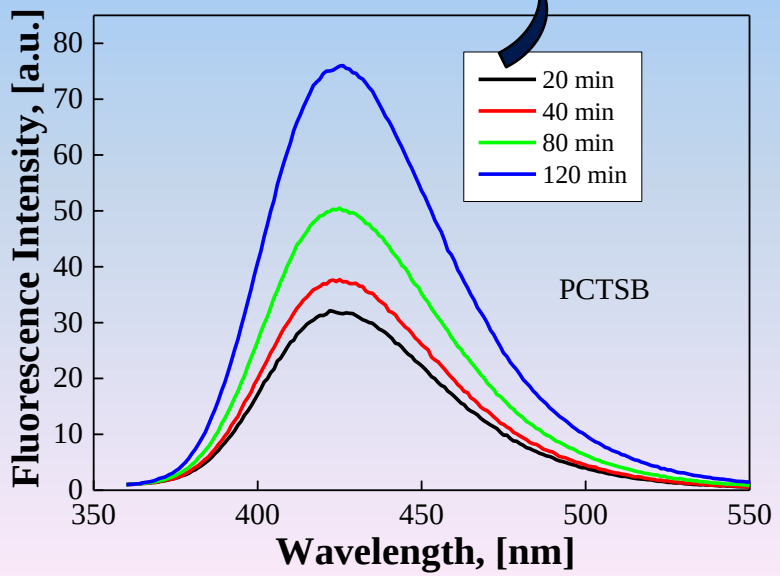
HO˙ radicals from the surface by fluorescence technique



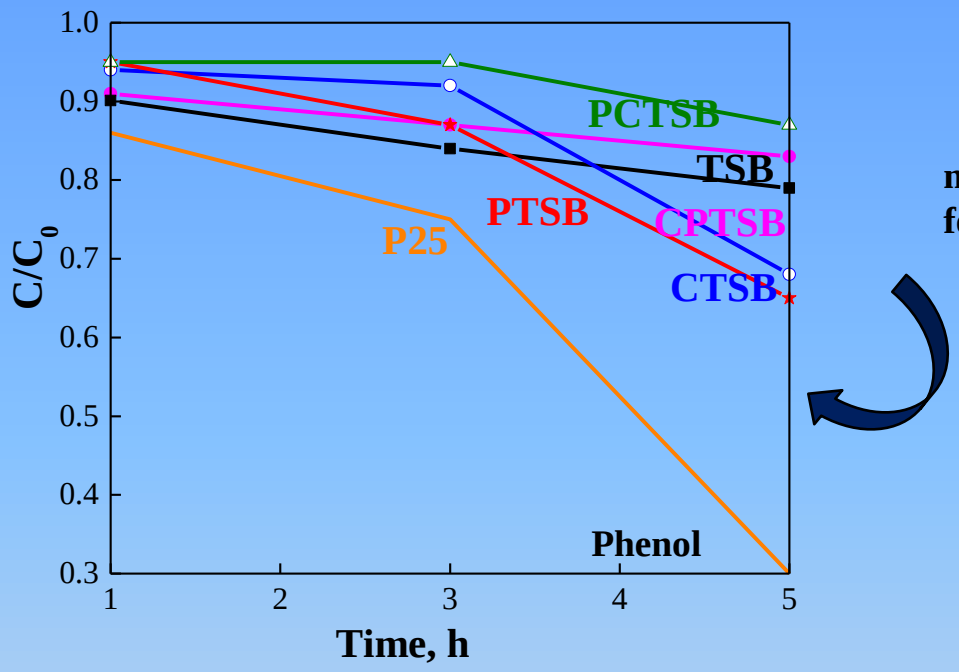


the significant effect of Pt addition





Photocatalytic degradation of phenols from water

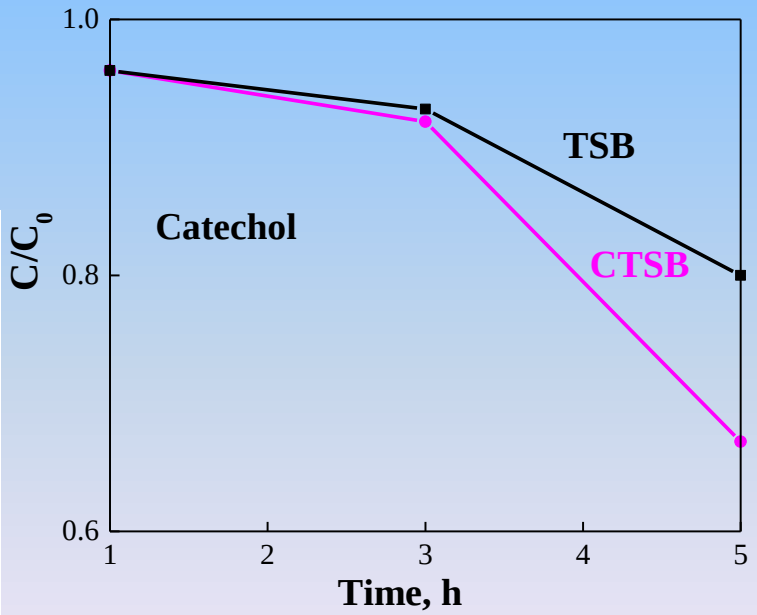


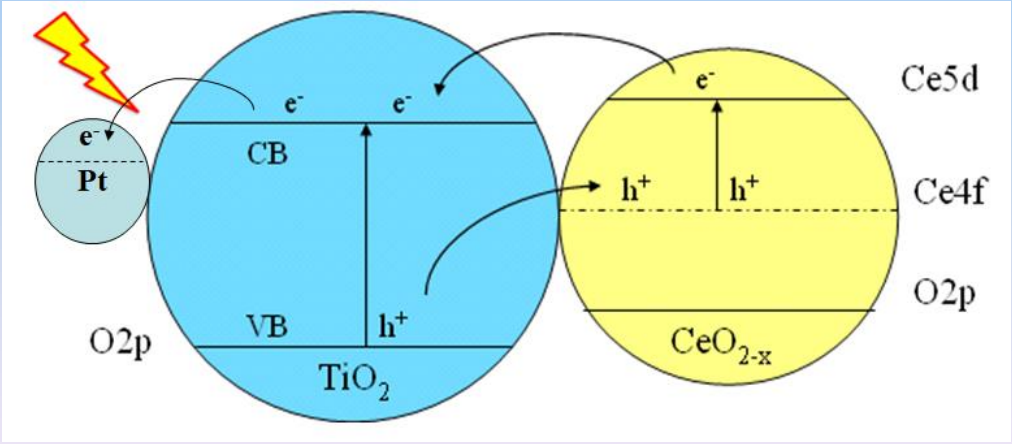
the higher activity

morphological changes of surface favored the formation of high mobile Ti hidroxide species

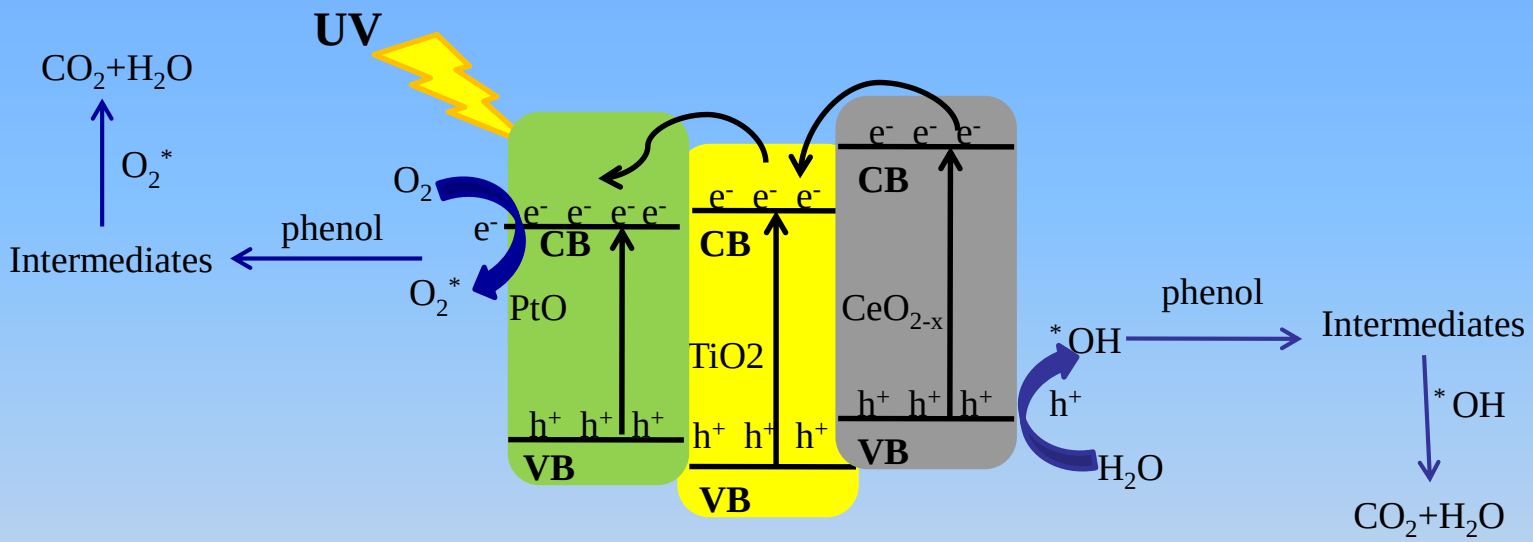
Working conditions:

ƛ= 254 nm; 2X10^{-4}M (fenol)
1X10^{-5}M (catechol)





Proposed mechanism



Conclusions

- **New catalysts were obtained with activity in photocatalytic oxidation of organic compounds**

- **XRD, N_2 adsorption-desorption, SEM and TEM results confirm preservation of mesoporous ordered structure, specially after the introduction of titanium and ceria**

- **The co-solvent changed the morphology and some characteristics of SBA-15 porous structure**

- **The best results in photocalalytic degradation of phenol were obtained for CTSB and PTSB samples**

- **These catalytic tests shown a competition between morphology, dispersion of Ti and Ce on the materials surface and a strong interaction between Ce and Ti**

- **Dispersion of TiO_2 on mesoporous silica and its doping with Ce or Pt is a good solution to obtain very active photocatalysts for degradation of phenols from water.**

Thank you for your attention!

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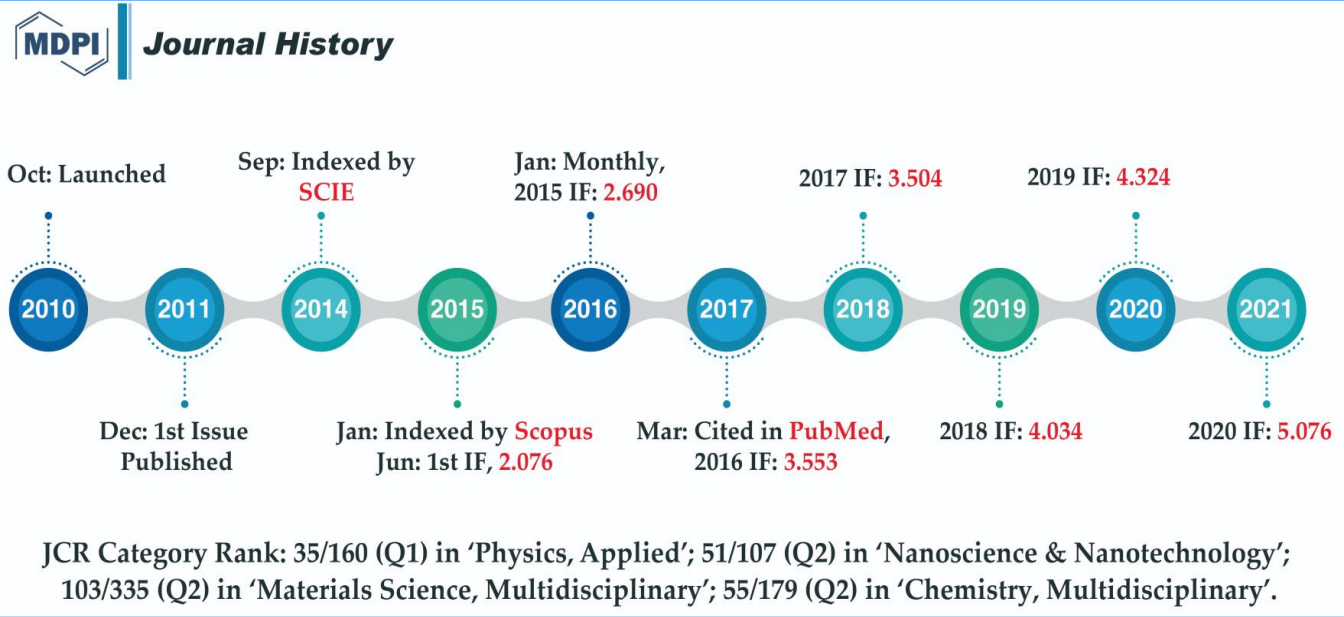

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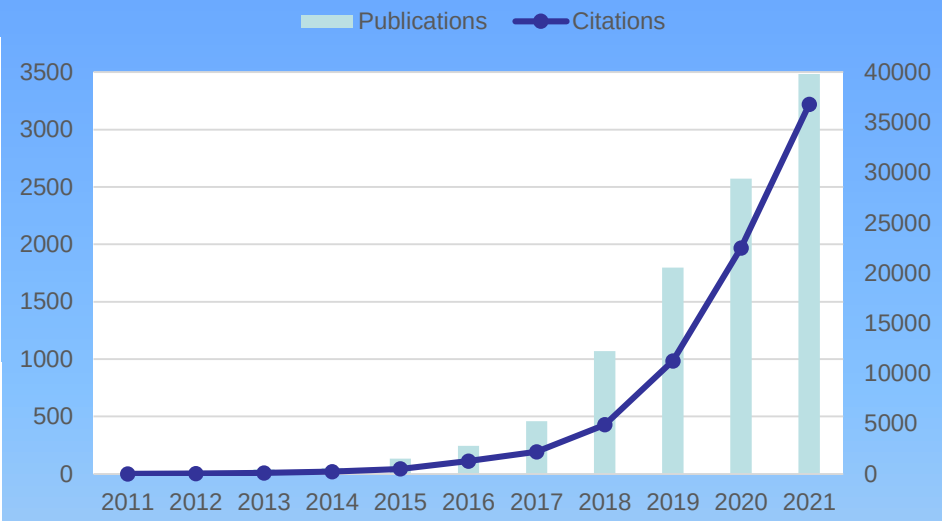

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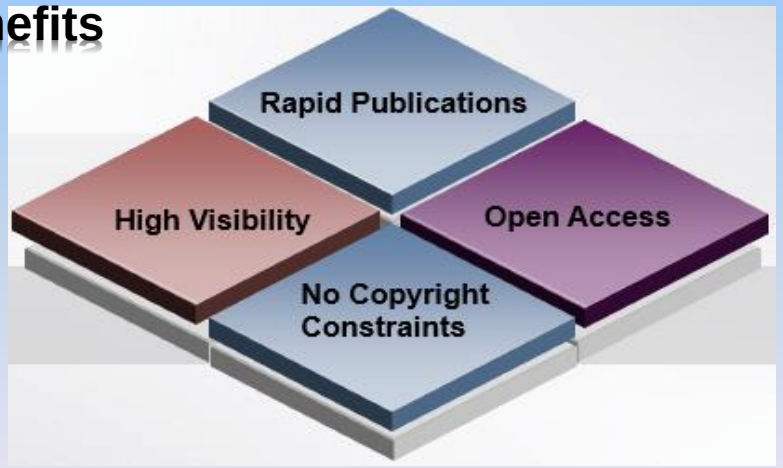

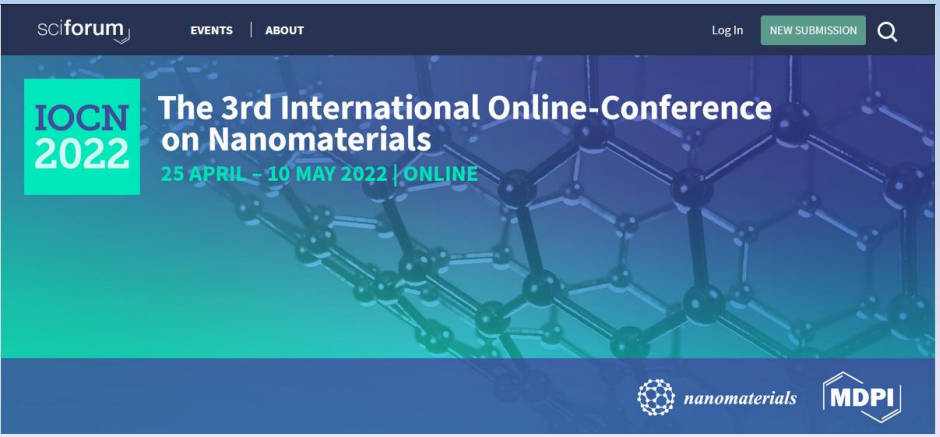

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