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Multifunctional Energy-Efficient Structural Materials

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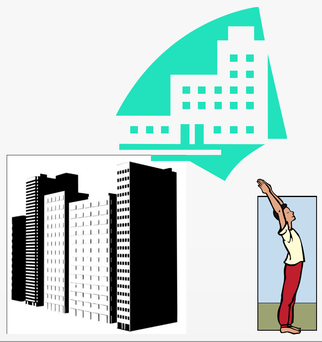
Motivation

A holistic approach to optimize the concrete performance by integrating advanced materials science, concrete technology, structural design and environmental sustainability.

What if building materials can save energy and clean themselves …?

Scientific Issues & Objectives

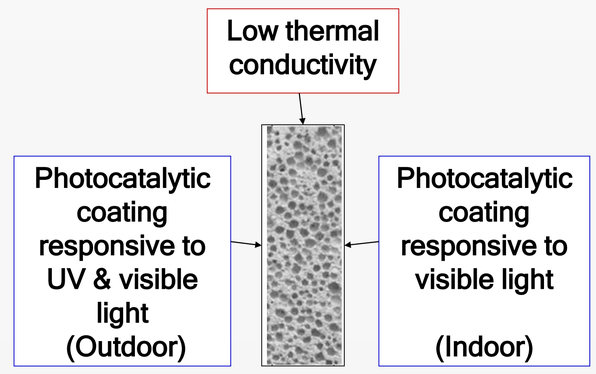
- Building sector: 37% energy consumption
- Buildings in use: 85% of the energy consumption for Cooling, heating, and lighting.
- Novel multifunctional structural materials for existing and future modern buildings in tropical regions: more energy efficient and environmental friendly.



Scientific Issues & Objectives

New multifunctional building materials:

- Energy saving, more durable, self clean, and better atmospheric environment.



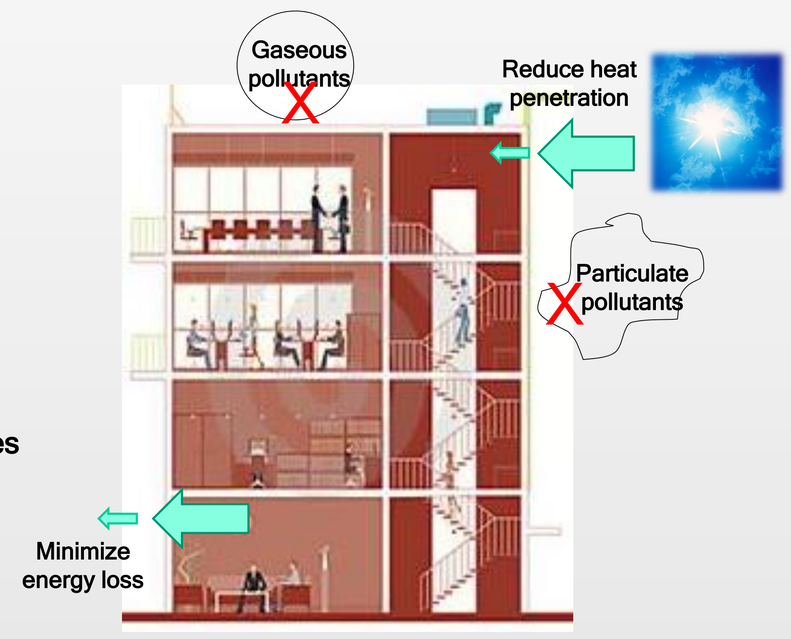
Approach

Energy efficient structural material

- Lightweight
- Low thermal conductivity
- Sufficient strength and elastic modulus, low shrinkage/creep for structural applications

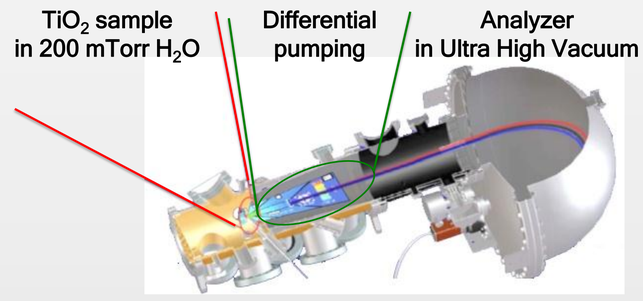
Environmental sustainable material

- Renewable abundant tropical light source
- Removal of airborne pollutants and self clean
- Enhanced durability through mechanistic studies



On going research:

Ambient pressure x-ray photoelectron spectroscopy



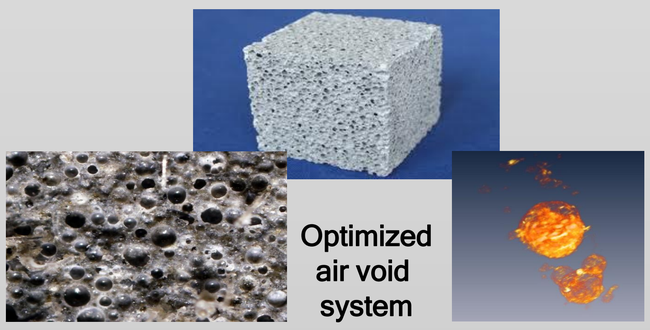
Goal: To study details of the reaction

$UV + TiO_2 \rightarrow TiO_2 (h^+ + e^-)$

$h^+ + H_2O \rightarrow H^+ + \bullet OH$

Current Understandings

	Density, kg/m3	Thermal conductivity, W/mK (Mindess et al. 2003)
Ordinary concrete	~2300	1.5 - 3.5
LW concrete	1360 - 1840	0.51 – 0.95
Air	-	0.03

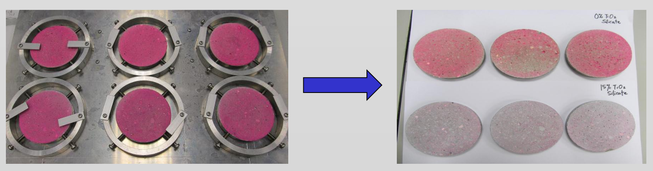


Optimized air void system

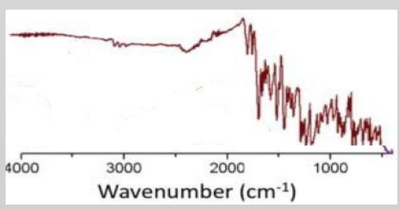
Current Understandings

Compromised durability due to masked active sites:

- Polymerized airborne compounds (Cao et al. 2000)
- High relative humidity (e.g., Luo et al. 1996, Wang et al. 2007)

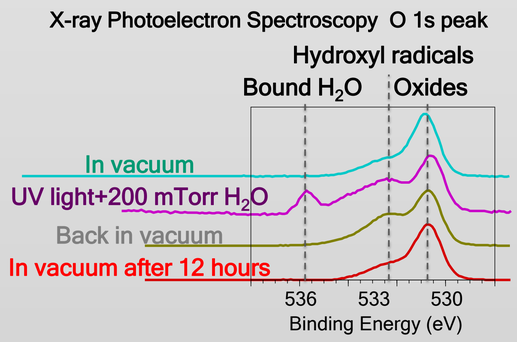


Photocatalytic degradation using renewable light source remove surrogate of particulate pollutants



Photocatalytic degradation of particulate pollutants: changes in functional groups are expected to be monitored via FTIR

Current findings

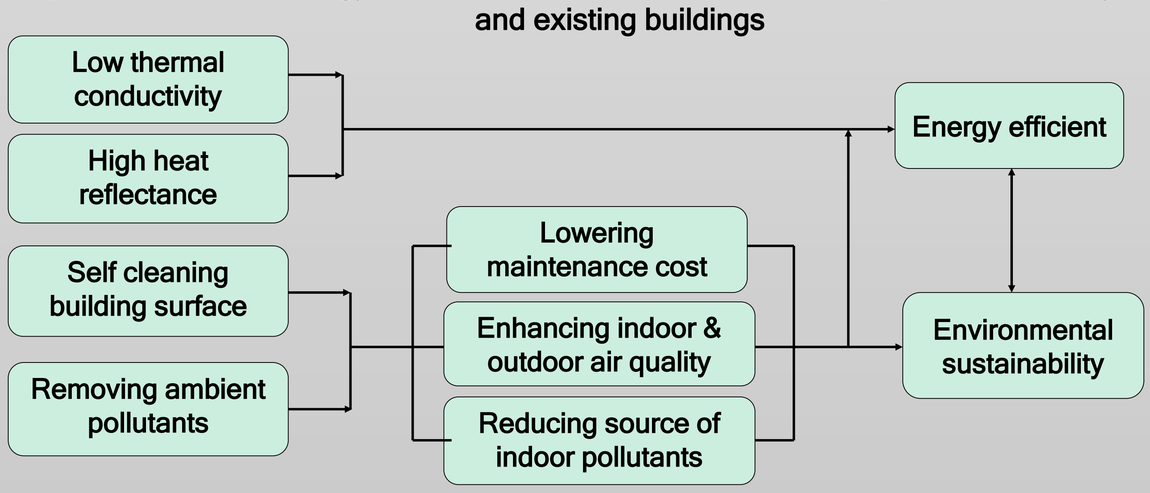


Summary:

We are able to observe photocatalytic activation of TiO_2 in-situ. Next we will study a) silicate coating with embedded TiO_2, and b) the oxidation of NO_2 by hydroxyl radicals.

Continuous Endeavor

To develop multifunctional energy efficient structural materials with multiple functions & synergy for future and existing buildings



References

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Luo et al. Heterogeneous photocatalytic oxidation of trichloroethylene and toluene mixtures in air: kinetic promotion and inhibition, time-dependent catlayst activity. Journal of Catalysis 1996; 163(1):1-11.

Wang et al. The kinetics of photocatalytic degradation of tricholoroethylene in gas phase over TiO_2 supported on glass bead. Applied catalysis B: Environmental 17(4): 313-20.