in.mat-Lab
Consulting & Laboratory Services

LiComPerl

DEVELOPMENT OF COMPOSITE LIGHTWEIGHT MATERIALS WITH UPGRADED PHYSICOCHEMICAL FUNCTIONALITY AND IMPROVED ECONOMIC FEASIBILITY

PI Annual Meeting Oct. 9th – 13th 2022

Perlite Institute
Associate member

Project's Scope (I)

Acquire know-how on the development of composite lightweight materials, which can be applied to a variety of materials and applications:

- **Perlite substrates** of different particle size distributions (coarse, medium, fine, ultrafine expanded grains) expanded at different conditions
- **Multi-functional materials** of various physicochemical characteristics as coatings, e.g. inorganic and/or organic, photocatalytic, nano-materials
- Different preparation techniques: **coating** and/or **impregnation**

⇓

VTCA based on optimization of physicochemical functionality

and therefore economics.

Project's Scope (II)

Applications:

- **Construction: lightweight & insulation**
  - Functional material: Aerogel, PCMs
  - Perlite grades: fine, medium, coarse
- **Environmental: Photocatalysis, oil & dye removal, water treatment (heavy elements)**
  - Functional material: nano- TiO_2 & ZnO, alginate, emulsifiers, chitosan
  - Perlite grades: medium, coarse, fine, ultra fines
- **Agriculture: hydroponics, soil beneficiation**
  - Functional materials: zeolite, nutrients
  - Perlite grades: coarse, medium

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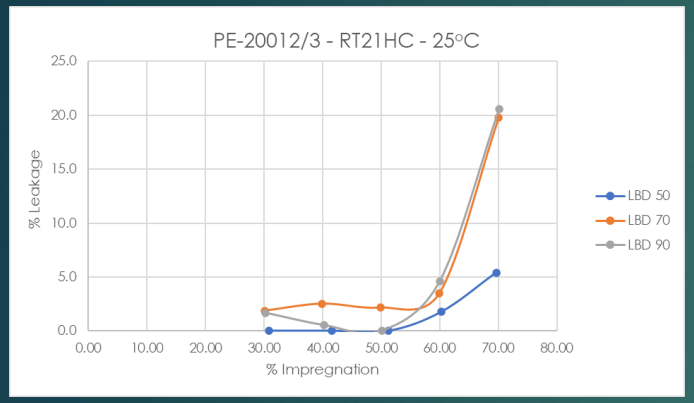
Application: Phase Change Materials (I)

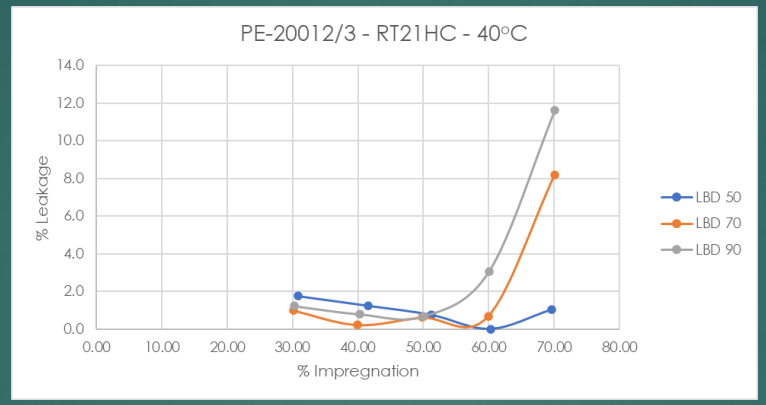
- **Materials**
  - Paraffins RT21 & RT31
  - Expanded Perlite grades
- **PCMs preparation**
  - Impregnation
  - Different %loading 30 – 70%w/w
- **Leakage Test**
  - Temperature: 25°C & 40°C
  - Time: 4h

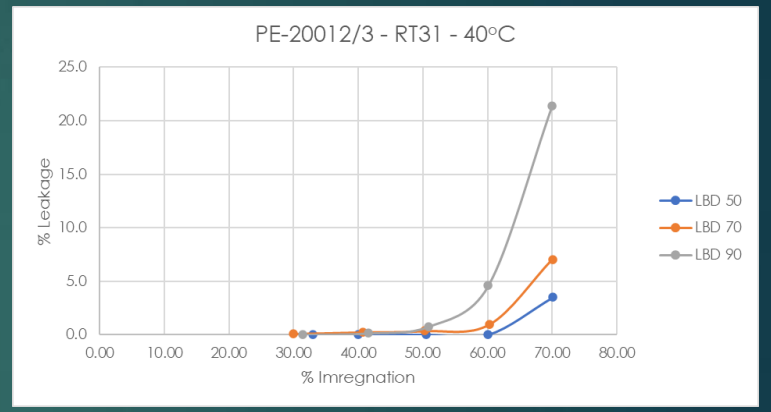
Grade / Code	LBD (Kg/m³)
Fine Grade 0.3/0.075 **PE-20012/3**	50
	70
	90
Medium Grade 1.2/0.5 **PE-20012/2**	110
	130
	170

Application: Phase Change Materials (II)

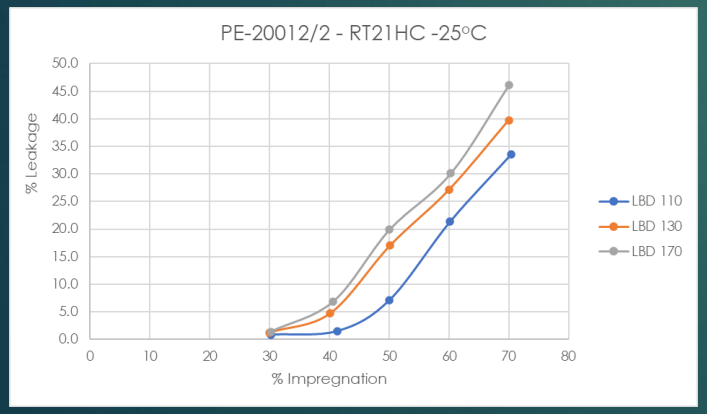
Leakage Tests of Fine Grades

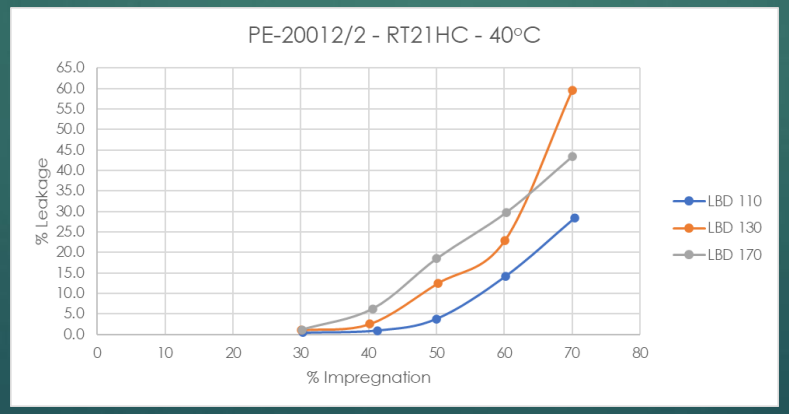


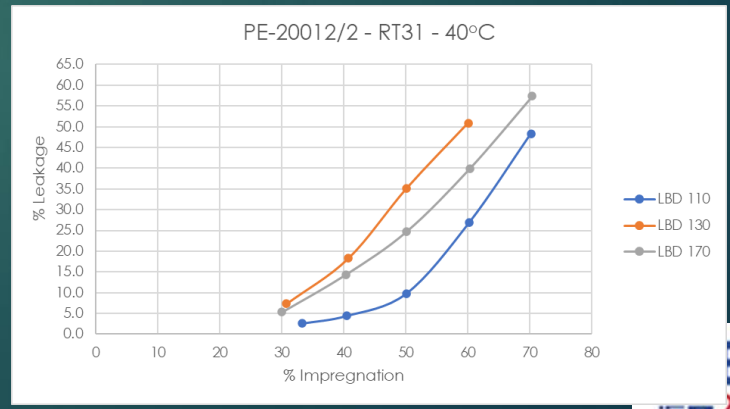




Leakage Tests of Medium Grades







Application: Phase Change Materials (III)

Conclusions

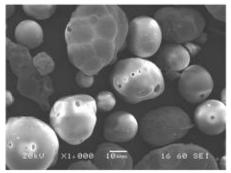
- Fine grades
  - Excellent behaviour without the need of external hydrophobation.
  - Leakage < 5% for loadings up to 70% w/w
- Medium grades
  - Moderate to bad behaviour
  - Leakage <5% for loading up to 40%

Future Work

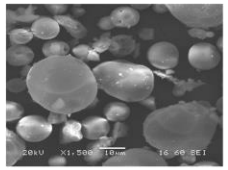
- Thermal Behaviour in plasters / mortars
  - Fine grades 50 – 70% impregnation loading

Application: Photocatalysis (I)

Step 1: Expansion of ultra-fine perlite grades



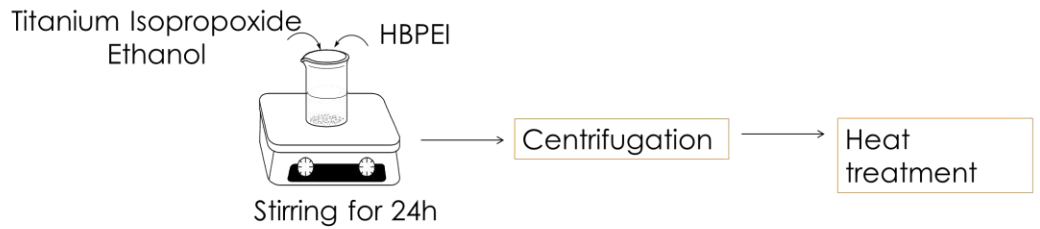
PE-20012/4-20



PE-20012/6-10

Code	LBD	Compresibility	Oil Absorption		Skeletal Density
ULTRA FINE	(kg/m³)	(%)	(g oil/g perlite)	(g oil/100cc perlite)	(kg/m³)
PE-20012/4-20	216	34.6%	1.17	25.7	1214.2
PE-20012/6-10	242	30.9%	0.94	22.7	1237.4

Step 2: Synthesis of TiO_2 nanospheres



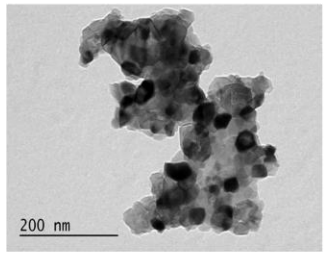
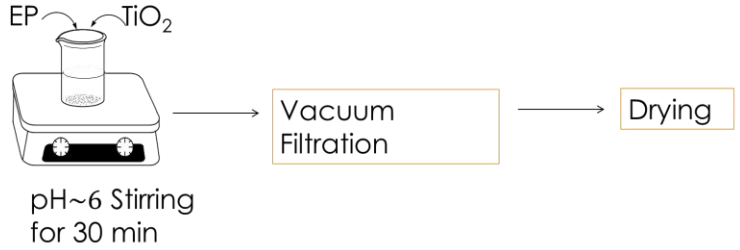


Fig. 1 Image of the TiO_2 nanoparticles obtained by TEM

Step 3: Synthesis of EP@TiO_2 photocatalyst



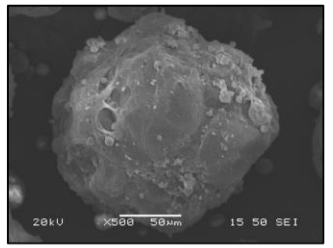


Fig. 2 Image of the EP@TiO_2 photocatalyst obtained by SEM

Application: Photocatalysis (II)

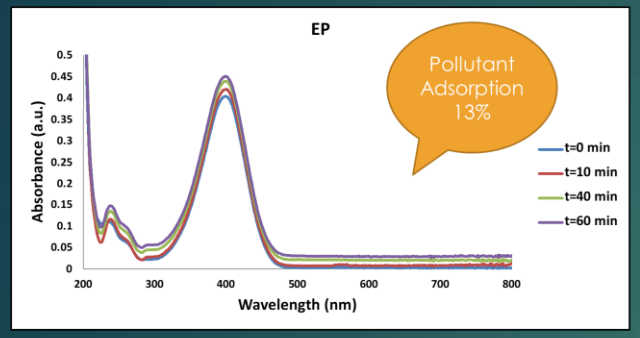


Fig. 4 Time-dependent UV–vis spectra for the reduction of 4-nitrophenol by $NaBH_4$ in the presence of EP

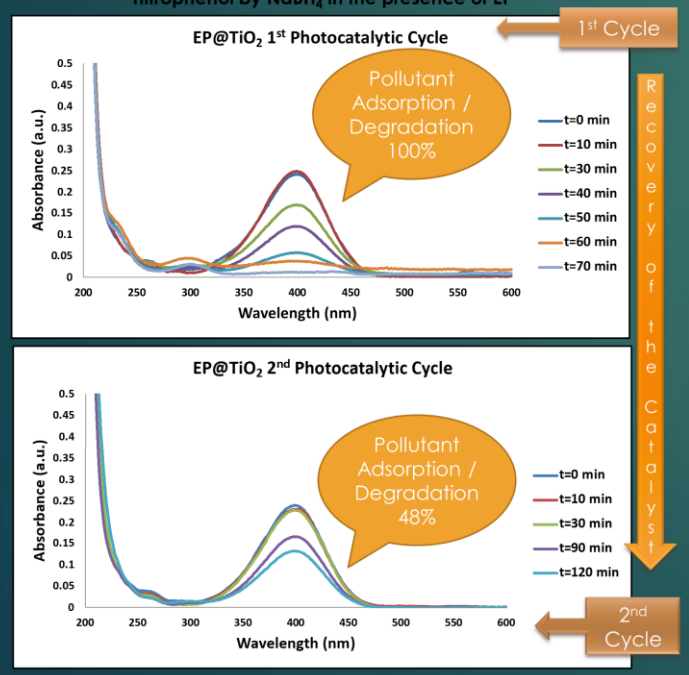


Fig. 5 Time-dependent UV–vis spectra for the reduction of 4-nitrophenol by $NaBH_4$ in the presence of $EP@TiO_2$ photocatalyst during first and second catalytic cycle

Conclusions

- Adsorption of 4-nitrophenol on the porous substrate - Degradation of the pollutant
- Complete adsorption/degradation within 70 min.
- Reusable photocatalyst (48% reduction within 2h during a 2nd cycle).

Future Work

- Production of photocatalysts with other nanomaterials, like ZnO etc.
- Preparation of photocatalytic renders
- Investigation of in-doors behavior (formaldehyde degradation)

Acknowledgement
This work was done in the School of Mining and Metallurgical Engineering, National Techn
University of Athens, which act as our subcontractor

Application: Heavy Elements Removal (I)

- **Materials**
  - Expanded Perlite grades
  - Chitosan (high molecular weight)
- **Composite materials' preparation**
  - Up to 50% Chitosan

Grades	LBD (Kg/m^3)
Ultrafines	225
	257
Fines	90
	120
	140
Medium	110
	170

Ultrafines/50%Chitosan w/w

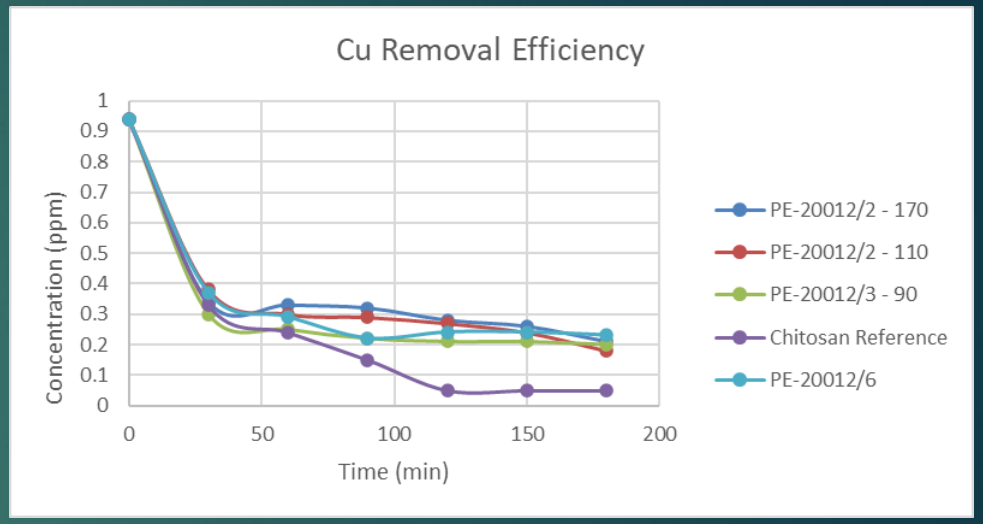
Fines90/50%Chitosan w/w

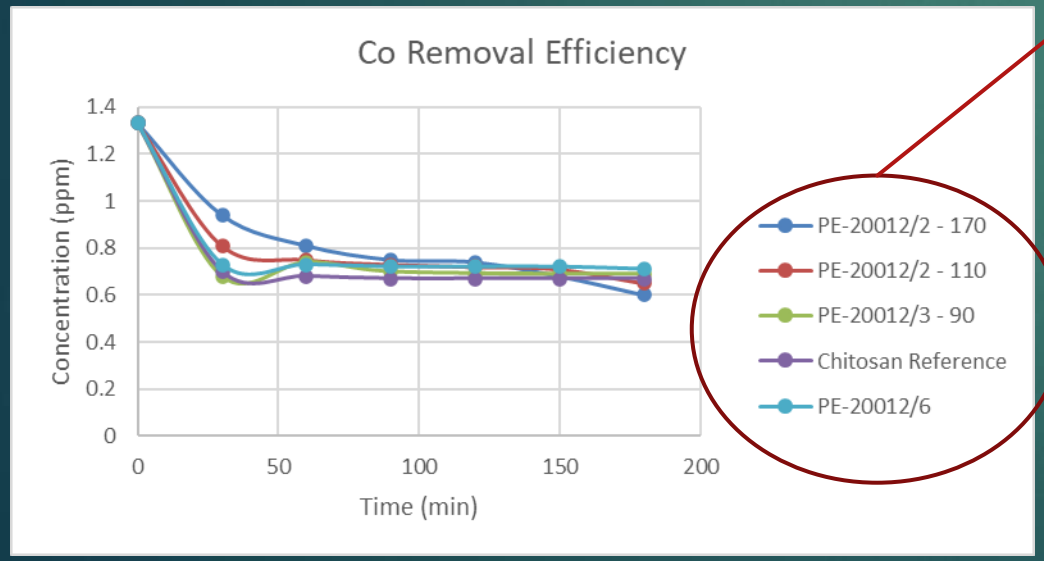
Medium110/50%Chitosan w/w

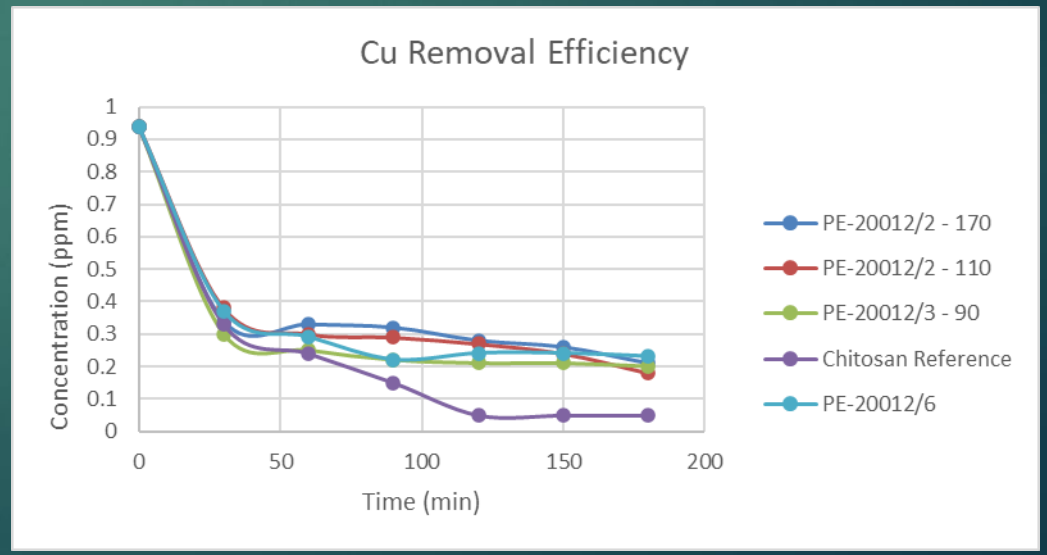
Application: Heavy Elements Removal (II)

- **Heavy elements removal**
  - Solution: 50 ppm Cu, 50 ppm Ni και 50 ppm Co
  - On-going

50% active material in the specimens





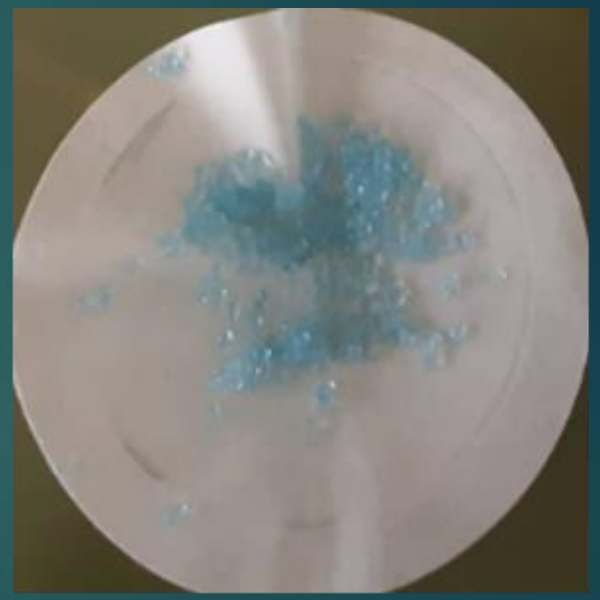


Application: Heavy Elements Removal (II)

- **Conclusions up to date**
  - Excellent behavior as far as % active material is concerned
  - Floatable – Easy to handle
- **Future Work**
  - Finalize optimum conditions
  - Upgrade TRL to filters for wastewater treatment

After Test

Medium/50%Chitosan w/w



Ultrafines/50%Chitosan w/w

Acknowledgements

- The project is funded by the Greek Ministry of Development and Investments within the Action "Research – Create – Innovate" of the platform NSRF PARTNERSHIP AGREEMENT 2014-2020 originating from the European Structural and Investment Funds (ESIF) of the European Union.

- In.mat-Lab would like to thank also Sunrise Resources & Patrick Cheetham for the provision of the raw perlite samples and the fruitful collaboration

Perlite Institute Associate member

Member of the National Startup Registry

Member of the Hellenic Federation of Enterprises SEV –Scale Up

Thank you for your attention

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