

## JOSEPH NATHANAEL



### About Faculty:

Dr. Joseph Nathanael, with 10 years of overseas research and teaching experience and more than a year of teaching and research experience at VIT, Vellore is an expert in the field of Biomaterials & Tissue Engineering. He completed his doctoral program at Bharathiar University, Coimbatore and spent three years as a post-doctoral fellow at South Korea. Subsequent to his post – doctoral stint, he joined Yeungnam University, South Korea, as an Assistant Professor (International Faculty Member). During that period, he was awarded a prestigious JSPS fellowship and worked in National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. (2015-18). He then served as a research Professor at the Yeungnam University for three years, before returning to India as a DBT Ramalingaswami Re-entry Fellow (2021). His current area of research includes 4D printed materials for tissue engineering applications, nanomaterial / polymer composites for wound healing and packaging applications, paper-based sensors for Point of Care Testing.

### Research Areas:

- Engineered nanomaterials for Bone Tissue Engineering Applications
- 3D and 4D Printed materials for Tissue Engineering Applications
- Nanomaterial/polymer composites for wound healing and food packaging applications.
- Paper based sensors for Point of Care Testing

### Contact Info:

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### Research Interest

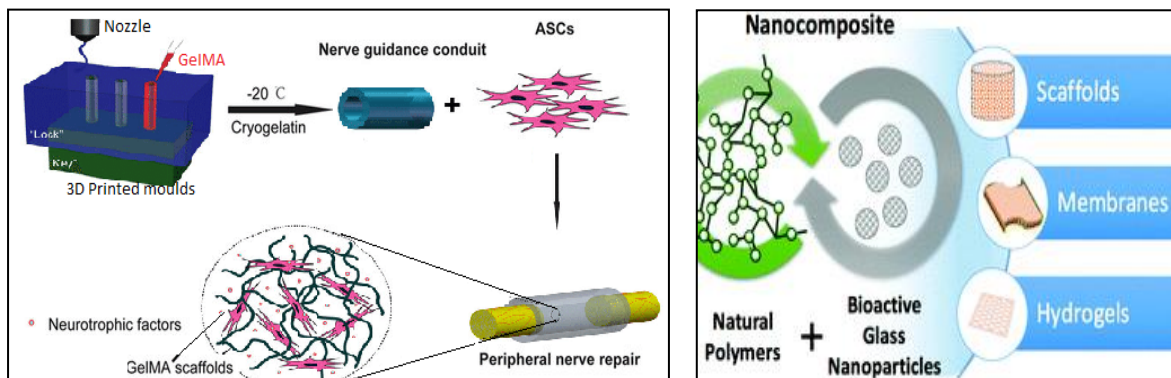
Nanocomposites offer opportunities on completely new scales for solving obstacles ranging from medical, pharmaceutical industry, food packaging, to electronics and energy industry. They have unique physical and chemical properties which can be used as a suitable additive for polymers to increase their performance. 3D printing holds strong potential for the formation of a new class of multifunctional nanocomposites. With the ability to print complex 3D objects layer by layer, additive manufacturing with nanomaterials could be leveraged in new ways toward greater control over material properties across part dimensions.

In one of our research works, we intend to develop a new type of Biodegradable Mesoporous Bioactive Monodisperse Glass nanoparticles (BGNPs) composited with inorganic ions for Bone Tissue. Initial development of BGNPs were done with and without different ions. Further analysis like porosity,

ion release studies etc are going on. 3D printing work has been started and different polymer samples and composite formation is under progress.

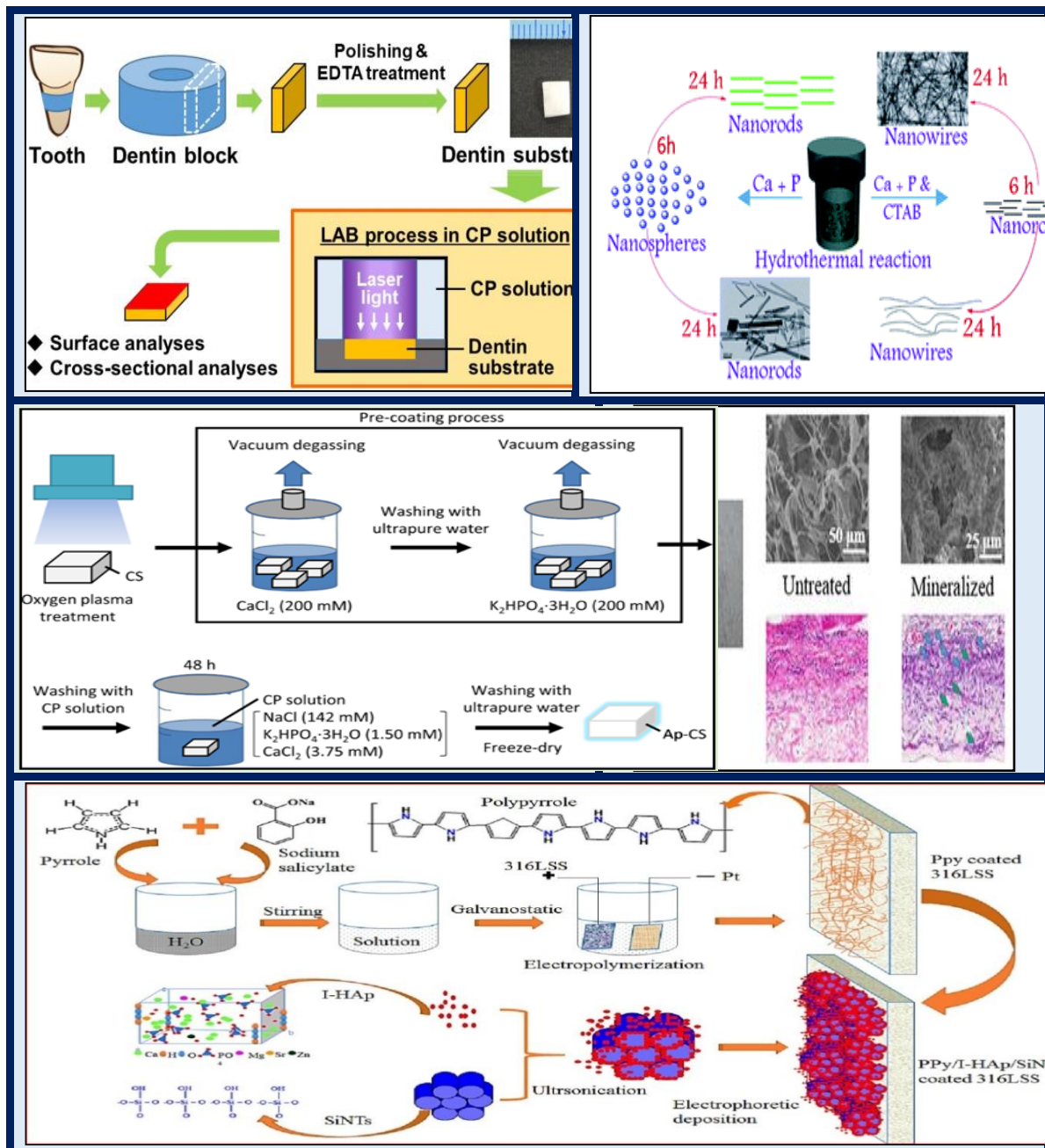
We also focus on developing nanocomposites and biopolymer-based films for active and smart food packaging. The incorporation of nano structured products (i.e., composites, barrier layers, sensors) provide distinct advantages such as stronger, flexible and high-barrier packaging materials, antimicrobial compounds with greater activity and sensors that can detect gases, pH changes or micro-organisms. Due to increasing concern of the environmental damage due to synthetic plastic packaging and consumers' awareness on harmful effects of synthetic inputs in food, biopolymer-based nanocomposites offer attractive alternatives to the traditional petroleum-based polymers.

Another area of study is Neural Tissue Engineering. The Nervous system is a complex assemblage of cells that controls all the functions of our body. Injuries to the Nervous system have a major impact on population, on medical and healthcare, social and economic field. Conventional medicine doesn't have effective treatment for the injuries and the existing cell-based therapies are not sufficient for the repair of neural tissue after damage. However, tissue engineering sheds light on this problem. Tissue engineering opts for the use of biocompatible three-dimensional biomaterials, cells, and bioactive molecules in order to restore the integrity of damaged tissue, respecting the original anatomy, while recovering its functionality. In our work, nerve conduit construct should provide a suitable environment for neuron survival and axonal extension, guide axonal projections, and mimic the biomechanics with adequate mechanical properties will be aided as a therapeutic approach in clinics.



## Research highlights

Dr. Joseph has expertise in various fields, the highlights of which are mentioned. He has expertise in nanomaterial and tissue engineering research. Current research areas include nanoparticle synthesis, 4D printing of composites for bone and neural tissue engineering applications, polymer composites for bone tissue engineering, biocomposite for active /smart food packaging and paper-based sensors for Point of care Testing.



## Honours & Awards

1. Visiting Research Scholar Indo-Taiwan collaborative project, Ministry of Higher Education, Taiwan (2008)
2. Brain-Korean (BK21) Post-doctoral Fellowship, South Korea (2010-12)
3. Awarded **JSPS** Fellowship (2015-18)
4. Recipient of **DBT Ramalingaswami Re-entry** Fellowship (2021-26)

## Grants

### Ongoing:

1. Four dimensional (4D) bioprinting of smart nanocomposite artificial bone ECM with shape memory and programmable therapeutic delivery functions, **DBT Ramalingaswami Re-entry Fellowship**, Govt. of India, funded Project' (File No. BT/HRD/35/02/2006). INR 1,13,60,000/- Duration 2021-2026 (Principal Investigator)
2. Low-cost paper based disposable sensor for CEA (Carcino Embryonic Antigen) detection for cancer screening. **VITSEED Grant** from Vellore Institute of Technology, Vellore (Principal Investigator).

### Research Publications (2010 ~ present):

#### 2022

- 1) Y. Kanemoto, H. Miyaji, E. Nishida, S. Miyata, K. Mayumi, Y. Yoshino, A. Kato, T. Sugaya, T. Akasaka, *Nathanael, A.J.* and S. Santhakumar, Periodontal tissue engineering using an apatite /collagen scaffold obtained by a plasma-and precursor-assisted biomimetic process. *Journal of Periodontal Research*, 57(1), pp.205-218. **2022**
- 2) Y. M. Im, A. *J.Nathanael*, M. H. Jung, S. O. Lee, & T. H. Oh, Effect of Polyethylene Glycol on Melt Spinning of Poly (Acrylonitrile-co-1-Vinylimidazole). *Fibers and Polymers*, 23(2), 321-326. **2022**
- 3) C. R. Dhas, S. Monica, K. Jothivenkatachalam, A. *J. Nathanael*, V. Kavinkumar, R. Venkatesh, & D. Arivukarasan, Direct-grown nebulizer-sprayed nickel-copper mixed metal oxide nanocomposite films as bifunctional electrocatalyst for water splitting. *Ionics*, 28(1), 383-396. **2022**

#### 2021

- 4) C. Ravi Dhas, S. E. Santhoshi Monica, R. Venkatesh, R. Sivakumar, A. *J. Nathanael*, R. Vignesh, & S. Keerthana, Correlation of annealing temperature on physico-chemical properties and electrochromic performance of nebulizer spray-coated NiO films. *Inorganic and Nano-Metal Chemistry*, 1-13. **2021**
- 5) C. Kalirajan, A. Dukle, A. *J. Nathanael*, T. H. Oh, & G. Manivasagam, A Critical Review on Polymeric Biomaterials for Biomedical Applications. *Polymers*, 13(17), 3015. **2021**
- 6) A. *J. Nathanael*, K. Kannaiyan, A. K. Kunhiraman, S. Ramakrishna, & V. Kumaravel, Global opportunities and challenges on net-zero CO<sub>2</sub> emissions towards a sustainable future. *Reaction Chemistry & Engineering*, 6(12), 2226-2247. **2021**
- 7) A. *J. Nathanael*, & T. H. Oh, Encapsulation of Calcium Phosphates on Electrospun Nanofibers for Tissue Engineering Applications. *Crystals*, 11(2), 199. **2021**
- 8) A. Devi VK, R. Shyam, A. Palaniappan, A. K. Jaiswal, T. H. Oh, & A. *J. Nathanael*, Self-healing hydrogels: Preparation, mechanism and advancement in biomedical applications. *Polymers*, 13(21), 3782. **2021**

#### 2020

- 9) A. J. Nathanael, & T. H. Oh, Biopolymer coatings for biomedical applications. *Polymers*, 12(12), 3061. **2020**
- 10) Y. M. Im, H. M. Choi, A. J. Nathanael, M. H. Jeong, S. O. Lee, S. N. Yun, & T. H. Oh, Effects of Glycerol on Melt Spinning of Polyacrylonitrile Copolymer and Tetrapolymer. *Fibers and Polymers*, 21(2), 376-383. **2020**
- 11) A. J. Nathanael, K. Kannaiyan, A. K. Kunhiraman, & V. Kumaravel, Nanomaterials for detection and removal of gases. In *Nanomaterials for Sustainable Energy and Environmental Remediation* (pp. 219-260). **2020**
- 12) A. J. Nathanael, Y. M. Im, & T. H. Oh, Intrinsic effect of anionic surfactant on the morphology of hydroxyapatite nanoparticles and its structural and biological properties. *Advanced Powder Technology*, 31(1), 234-240. **2020**

## 2019

- 13) A. Oyane, N. Saito, I. Sakamaki, K. Koga, M. Nakamura, A. J. Nathanael, N. Yoshizawa, K. Shitomi, K. Mayumi, and H. Miyaji. "Laser-assisted biomineralization on human dentin for tooth surface functionalization." *Materials Science and Engineering: C* 105 : 110061. **2019**
- 14) Y. J. Kim, H. M. Choi, S. H. Jang, K. H. Min, A. J. Nathanael, T. H. Oh. "Effect of encapsulation with zeolite and coating with TiO<sub>2</sub> on the thermal stability of caffeine during melt extrusion of a PET/TiO<sub>2</sub>@(zeolite/caffeine) nanocomposite." *Advanced Powder Technology* 30, no. 4: 854-860 **2019**.

## 2018

- 15) Y. J. Kim, H. M. Choi, S. H. Jang, K. H. Min, A. J. Nathanael, T. H. Oh, Effect of encapsulation with zeolite and coating with TiO<sub>2</sub> on the thermal stability of caffeine during melt extrusion of a PET/TiO<sub>2</sub>@(zeolite/caffeine) nanocomposite, *Advanced Powder Technology*, 30 (2019) 854-860.
- 16) A. J. Nathanael, A. Oyane, M. Nakamura, M. Mahanti, K. Koga, K. Shitomi, H. Miyaji, Rapid and area-specific coating of fluoride-incorporated apatite layers by a laser-assisted biomimetic process for tooth surface functionalization, *Acta Biomaterialia*, 79, 148-157, **2018**.
- 17) A. J. Nathanael, A. Oyane, M. Nakamura, K. Koga, E. Nishida, S. Tanaka, H. Miyaji, Calcium phosphate coating on dental composite resins by a laser-assisted biomimetic process, *Heliyon* 4, e00734 (1-16), **2018**.
- 18) G. S. Kim, A. J. Nathanael, Y. J. Kim, T. H. Oh, Preparation of TiO<sub>2</sub>-coated ZnO nanoparticles and their effect on the UV absorption of a poly(vinyl alcohol) composite film, *Fibers and Polymers* 19, 1747-1752, **2018**.

## 2017

- 19) A. J. Nathanael\*, A. Oyane, M. Nakamura, I. Sakamaki, E. Nishida, Y. Kanemoto, H. Miyaji, In vitro and in vivo analysis of mineralized collagen based sponges prepared by a plasma and precursor assisted biomimetic process, *ACS Applied Materials and Interfaces* 9, 22185-22194, **2017**.

## 2016

- 20) A. J. Nathanael, S. I. Hong, T. H. Oh, Y. H. Seo, D. Singh, S. S. Han, Enhanced cell viability of hydroxyapatite nanowires by surfactant mediated synthesis and its growth mechanism. *RSC Advances* 6, 25070-25081, **2016**.
- 21) K. P. Ananth, A. J. Nathanael, S. P. Jose, T. H. Oh, D. Mangalaraj, A novel silica nanotube reinforced ionic incorporated hydroxyapatite composite coating on polypyrrole coated 316L SS for implant application, *Materials Science & Engineering C - Materials For Biological Applications* 59, 1110-1124, February 1 **2016**
- 22) K.P. Anand, S. Jose, A.J. Nathanael, T.H. Oh, D. Mangalaraj, A.M. Ballamurugan, A Novel Modified Sol-Gel Template Synthesis of High Aspect Ratio Silica Nanotubes in the Presence of Phosphoric Acid, *Journal of Nano Research* 35, 27-38, July **2016**

## 2015

- 23) K. P. Ananth, A. J. Nathanael, S. P. Jose, T. H. Oh, D. Mangalaraj, A.M. Ballamurugan, Controlled electrophoretic deposition of HAp/ $\beta$ -TCP composite coatings on piranha treated 316L SS for enhanced mechanical and biological properties, *Applied Surface Science*, 353, 189-199, October **2015**.
- 24) K. P. Ananth, S. Shanmugam, S. P. Jose, A.J. Nathanael, T. H. Oh, D. Mangalaraj and A.M. Ballamurugan. Structural and chemical analysis of silica doped  $\beta$ -TCP ceramic coatings on surgical grade 316L SS for possible biomedical application, *Journal of Asian Ceramic Societies*, 3, 317-324, September **2015**.
- 25) A.J. Nathanael, Y.M.Im, T.H. Oh, R. Yuvakkumar, D. Mangalaraj, Biomimetic hierarchical growth and self-assembly of hydroxyapatite/titania nanocomposite coatings and their biomedical applications, *Applied Surface Science* 332, 368-378, March, **2015**.
- 26) A.J. Nathanael, Y.H.Seo, T.H. Oh, PVP Assisted synthesis of hydroxyapatite nanorods with tunable aspect ratio and bioactivity, *Journal of Nanomaterials*, 2015 (621785), 1-9, March, **2015**.
- 27) Y.M.Im, T.H. Oh, A.J. Nathanael, S.S. Jang Effect of ZnO nanoparticles morphology on UV blocking of poly(vinyl alcohol)/ZnO composite nanofibers, *Materials Letters*, 147, 20-24, May, **2015**.
- 28) R. Yuvakkumar, J. Suresh, B. Saravanakumar, A. J. Nathanael, S. I. Hong, V. Rajendran, Rambutan peels promoted biomimetic synthesis of bioinspired zinc oxide nanochains for biomedical applications, *Spectrochimica Acta Part A-Molecular and Biomolecular Spectroscopy*, 137, 250-258, February **2015**
- 29) R. Yuvakkumar, P. Perantham, A. J. Nathanael, D. Nataraj, D. Mangalaraj, S. I. Hong, Macroparticles Reduction Using Filter Free Cathodic Vacuum Arc Deposition Method in ZnO Thin Films, *Journal of Nanoscience and Nanotechnology* 15, 2523-2530, March **2015**.
- 30) K.P. Anand, S. Jose, A.J. Nathanael, T.H. Oh, D. Mangalaraj, A.M. Ballamurugan, Biomimetic Ion Substituted Hydroxyapatite Coating On Surgical Grade 316L SS For Implant Applications, *Advanced Materials Letters* 6, 984-989, November **2015**.

## 2014

- 31) A.J. Nathanael, R. Yuvakkumar, S.I. Hong, T.H. Oh, Novel zirconium nitride and hydroxyapatite nanocomposite coating: Detailed analysis and functional properties, *ACS Applied Materials & Interfaces* 6 (12), 9850-9857, June, **2014**
- 32) A.J. Nathanael, J.H. Lee, D. Mangalaraj, S.I. Hong, T.H. Oh, Influence of processing method on the properties of hydroxyapatite nanoparticles in the presence of different citrate ion concentrations. *Advanced Powder Technology* 25(2),551-559, March, **2014**
- 33) Y.M.Im, T.H. Oh, J.W. Cha, Y.H.Seo, J.S. Hwang, A.J. Nathanael, S.S. Han, S.H. Jang, Preparation of poly(vinyl alcohol)/ZrO<sub>2</sub> composite nanofibers via co-axial electrospinning with higher ZrO<sub>2</sub> particle content, *Fibers and Polymers* 15 (10), 2066-2071, October, **2014**.
- 34) R. Yuvakkumar, A.J.Nathanael,S.I. Hong, Inorganic complex intermediate Co<sub>3</sub>O<sub>4</sub> nanostructures using green ligation from natural waste resources,*RSC Advances*, 4 (84), 44495-44499, September, **2014**
- 35) R. Yuvakkumar, J. Suresh, A.J. Nathanael, M. Sundrarajan, S.I. Hong, Novel green synthetic strategy to prepare ZnO nanocrystals using rambutan (*Nepheliumlappaceum*L.) peel extract and its antibacterial applications, *Materials Science and Engineering C* 41,17-27, August, **2014**.
- 36) R. Yuvakkumar, J. Suresh, A.J. Nathanael, M. Sundrarajan, S.I. Hong, Rambutan (*Nepheliumlappaceum* L.) peel extract assisted biomimetic synthesis of nickel oxide nanocrystals, *Materials Letters* 128,170-174, August, **2014**.
- 37) R.Yuvakkumar, A. J.Nathanael, V. Rajendran, S. I. Hong, Rice husk ash nanosilica to inhibit human breast cancer cell line (3T3),*Journal of Sol-Gel Science and Technology*, 72, 198-205,October **2014**.
- 38) S. R. Kumar, L. Marianna, S. Gianni, A J. Nathanael, S.I. Hong, T.H. Oh, D.Mangalaraj, C. Viswanathan, N.Ponpandian, Hydrophilic polymer coated monodispersed Fe<sub>3</sub>O<sub>4</sub> nanostructures and their cytotoxicity,*Materials Research Express* 1 (015015), 1-15, January, **2014**.
- 39) R. Yuvakkumar, J. Suresh, A.J. Nathanael, M. Sundrarajan, S.I. Hong, A Comparative Study on Antibacterial and Wash Durability Behaviour of ZnO and CuO Nanoparticles Treated Cotton Fabric Using Sodium Alginate as Cross Linker, *Applied Mechanics and Materials*, 508, 44-47, **2014**.
- 40) A.J. Nathanael, R. Yuvakkumar, T.H. Oh, S.I. Hong, High Aspect Ratio Hydroxyapatite Nanorods Formed by Polymer Assisted Synthesis, *Applied Mechanics and Materials*, 508, 52-55, **2014**.
- 41) J. Suresh, R. Yuvakkumar, A.J. Nathanael, M. Sundrarajan, S.I. Hong, Antibacterial and Wash Durability Properties of Untreated and Treated Cotton Fabric Using MgO and NiO Nanoparticles, *Applied Mechanics and Materials*, 508, 48-51, **2014**.

## 2013

- 42) A.J. Nathanael, S. Han, T.H. Oh, Polymer assisted hydrothermal synthesis of hierarchically arranged hydroxyapatite nanoceramic, *Journal of Nanomaterials*, 2013, 962026, 1-8, June, **2013**.
- 43) A J. Nathanael, D. Mangalaraj, S.I. Hong, Y. Masuda, Y.H. Rhee, H.W. Kim, Influence

of fluorine substitution on the morphology and structure of hydroxyapatite nanocrystals prepared by hydrothermal method, *Materials Chemistry and Physics* 137 (3) 967-976, January, **2013**.

- 44) A.J. Nathanael, Lee, I. H., Lee, K. H. S. I. Hong, Solvothermal Synthesis and Detailed Analysis of Hydroxyapatite Nanostructure, *Advanced Materials Research*, 683, 322-325, **2013**.
- 45) A. J. Nathanael, J. H. Lee, S. I. Hong, Nanocomposited and functionally graded ZrN/HA coatings on cp-Ti by RF magnetron sputtering, *Applied Mechanics and Materials*, 248, 37-42, **2013**.

## **2012**

- 46) A.J. Nathanael, S.I. Hong, D. Mangalaraj, N. Ponpandian, P.C. Chen. Template free growth of novel hydroxyapatite nanorings: formation mechanism and their enhanced functional properties, *Crystal Growth & Design*, 12 (7), 3565-3574, May, **2012**.
- 47) A.J. Nathanael, J.H. Lee, D.Mangalaraj, S.I. Hong, Y.H. Rhee, Multifunctional activity of hydroxyapatite / titania bio-nano-composites: bioactivity and antimicrobial studies, *Powder Technology*, 228 , 410-415, September, **2012**.
- 48) A.J. Nathanael, J.H. Lee, S.I. Hong, Effect of processing parameters on the mechanical reliability of ZrN/ hydroxyapatite nanocomposite coatings, *Advanced Science Letters*, 15,285-290, August, **2012**.
- 49) H. Y. Kwak, K. H. Lee, A. J. Nathanael, S. I. Hong, Mechanical properties of Cu-Ag micro-composites thermo-mechanically processed by equal channel angular pressing (ECAP), *Advanced Science Letters*, 14, 849-53, August, **2012**
- 50) J. H. Lee, A. J. Nathanael, S. I. Hong, Effect of nitrogen flow rate on the structure and properties of TiN thin films deposited onto  $\beta$ -type Ti-15Mo-3Nb-3Al-0.2Si alloy substrates by reactive magnetron sputtering, *Advanced Materials Research*, 557-559, 1998-2001, August **2012**.

## **2011**

- 51) A.J. Nathanael, S.I. Hong, D. Mangalaraj, P.C. Chen, Large scale synthesis of hydroxyapatite nanospheres by high gravity method, *Chemical Engineering Journal*, 173 (3), 846-854, October, **2011**.
- 52) A.J. Nathanael, D. Mangalaraj, P.C. Chen, N. Ponpandian, Enhanced mechanical strength of hydroxyapatite nanorods reinforced with polyethylene, *Journal of Nanoparticle Research*, 13 (5), 1841-1853, May, **2011**.
- 53) A.J. Nathanael, D. Mangalaraj, S.I. Hong, Y. Masuda, Synthesis and in-depth analysis of highly ordered yttrium doped hydroxyapatite nanorods prepared by hydrothermal method and its mechanical analysis, *Materials Characterization*, 62 (12), December, 1109-1115, **2011**.
- 54) J.M. Lee, A. J. Nathanael, P.W. Shin, S.I. Hong, Y.H. Jeong, Mechanical and Oxidation Properties of Cold-Rolled Zr-Nb-O-S Alloys, *Korean Journal of Materials Research*, 21(3), 161-167, March, **2011**.



**2010**

- 55) A.J. Nathanael, D. Mangalaraj, P.C. Chen, N. Ponpandian, Mechanical and photocatalytic properties of hydroxyapatite/titania nanocomposites prepared by combined high gravity and hydrothermal process, *Composites Science and Technology*, 70 (3), 419-426, March, **2010**.
- 56) A. J. Nathanael, D. Mangalaraj, N. Ponpandian, Controlled growth and investigations on the morphology and mechanical properties of hydroxyapatite/titania nanocomposite thin films, *Composites Science and Technology*, 70 (11), 1645-1651, October, **2010**.
- 57) A. J. Nathanael, D. Mangalaraj, P.C. Chen, N. Ponpandian, Nanostructured leaf like hydroxyapatite/TiO<sub>2</sub> composite coatings by simple sol-gel method, *Thin Solid Films* 518 (24), 7333-7338, October, **2010**.
- 58) A. J. Nathanael, D. Mangalaraj, P.C. Chen, D. Nataraj, Improved mechanical property of hydrothermally synthesized hydroxyapatite nanorods reinforced with polyethylene, *International Journal of Modern Physics B*, 24 (1&2), 215-223, January, **2010**.
- 59) A. J. Nathanael, D. Mangalaraj, J. S. Yi, Morphological variations of hydroxyapatite by different preparation methods, *Advanced Materials Research*, 123-125, 335-338, **2010**.

#### **Book Chapters:**

- 1) A. J. Nathanael, & T. H. Oh, Photodegradation of Air Pollutants. *Photocatalysis*, 163. De Gruyter
- 2) A. J. Nathanael, & P. S. Kumar, Composite Nanocoatings for Environmental Remediation. *Handbook of Consumer Nanoproducts*, 1-17. Springer
- 3) A. J. Nathanael, T. H. Oh, V. Kumaravel, Chapter 6: "Designing Smart Nanotherapeutics" in "Toxicity of Nanomaterials in the Environment" to be published by CRC Press, Taylor and Francis Group, UK (In press)
- 4) A. J. Nathanael, K. Kannaiyan, K. Vignesh, Chapter 13- "Nanomaterials for detection and removal of gases" Elsevier. (In press)

#### **Research group:**

#### **Current Members:**



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**Position: DBT –JRF**

**Project Title:** 4D bioprinting of smart nanocomposite artificial bone ECM with shape memory and therapeutic delivery functions.



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**Area of Interest:**

Stem Cells and Neural Tissue Engineering



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**Area of Interest:**

Biomaterials and Nanocomposites

**Capstone Project ongoing:**

**Bewin Leander**

**Project Title:** Optimisation of Microfluidic Channels in paper-based sensors