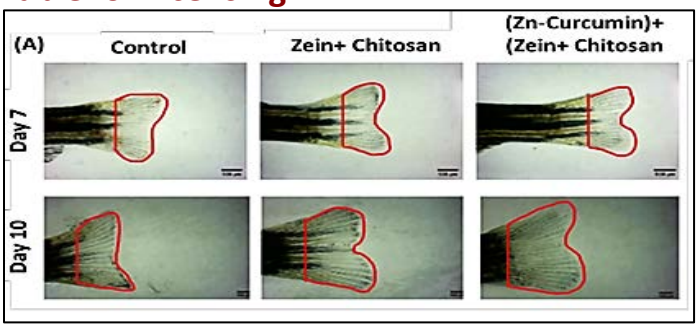
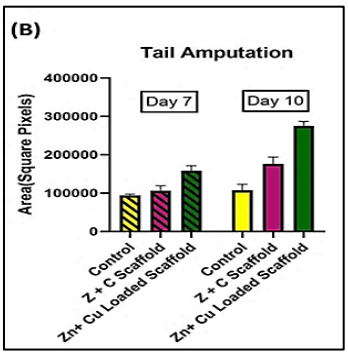
METAL-LIGAND COMPLEX LOADED HYDROGEL COMPOSITES AND METHODS OF PREPARATION THEREOF

IITM Technology Available for Licensing

Problem Statement

- Large bone or vascular defects are beyond the body's natural ability to repair itself. Such conditions require medical intervention to restore structure, function, and proper healing.
- Doctors use autografts (patient's own bone), allografts (donor bone), or synthetic grafts . Each has drawbacks like pain, rejection, infection, or poor integration.
- Bone tissue engineering uses biomaterials and hydrogels, but current options lack strength, uniform pores, and bioactivity. Curcumin (from turmeric) is promising but unstable and poorly soluble.
- A new composite is needed that is safe, customizable, and actively promotes healing. This invention provides a **zinc-curcumin loaded hydrogel sponge** supports bone growth, blood vessel formation, reduces inflammation, and dissolves naturally after healing.





Figures 2(a) and 2(b) : illustrate **the angiogenic potential of the zinc–curcumin** composite. show enhanced blood vessel formation improved vascularization, supporting its application in bone tissue regeneration.

Intellectual Property

- **IITM IDF Ref 3344**
- **IN 202541066546 Patent Application**

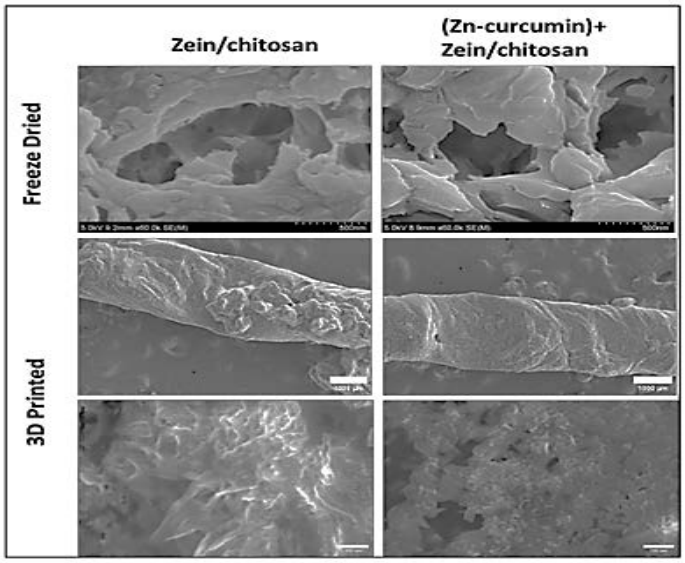


Figure 1: illustrates the porous**, interconnected structure of freeze-dried and 3D-printed** composites, highlighting their suitability for nutrient diffusion, cell infiltration, and bone tissue regeneration.

TRL (Technology Readiness Level)

TRL 4, Technology validated in lab

Technology Category/ Market

Category- Medical & Surgical devices

Industry:

Healthcare & Medical Devices, Biotechnology & Tissue Engineering

Applications:

Orthopedics, Vascular surgery, Periodontal regeneration , Tissue engineering models, Cell culture scaffolds, Bioactive implants, Animal orthopedics.

Market report: The size of the hydrogel market is expected to be an estimated value of **USD 3.9 Billion in 2025** and is anticipated to expand at a **6.6% CAGR** between 2025 and **USD 7.5 Billion by 2035.**

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Technology

The final product is implanted into bone or vascular defects. It acts as a **bioactive sponge,** guiding cells to grow, blood vessels to form, and tissue to regenerate, while dissolving naturally over time.

A hydrogel scaffold is made from natural polymers **chitosan and zein.** Into this scaffold, a **zinc–curcumin complex** is loaded to give healing properties.

Curcumin (from turmeric) is mixed with zinc salts in ethanol to form a stable bioactive complex. This **stabilizes curcumin and enhances its effectiveness in bone** and vascular healing.

Chitosan and zein are dissolved to form the amphiphilic hydrogel base. The **zinc–curcumin complex is blended into this base** to create a uniform bioactive mixture

Crosslinking agents (like calcium chloride) strengthen the **hydrogel network**. The composite is **shaped using freeze-drying (to** create pores) **or 3D printing** (to match defect shapes).

Key Features / Value Proposition

Balanced Polymer Ratio

- The hydrogel matrix is formed using hydrophilic (chitosan) and hydrophobic (zein) polymers in a weight ratio ranging from **1:10 to 5:1,** preferably **1:8 to 3:1**.
- This balance ensures both strength and bioactivity.

Zinc Concentration Range

- The zinc in the zinc–curcumin complex is present in very small amounts: **0.0001% to 5% by weight**, with preferred ranges like **0.00016% to 0.009%.**
- These trace levels are enough to stimulate bone healing without toxicity.

Curcumin Loading

- Curcumin (or its derivatives) is included at **0.0003% to 0.001% by weight**, with an optimal **concentration of about 0.000737%.**
- This provides antioxidant and osteogenic activity while overcoming curcumin's poor solubility.

Polymer Content

- Hydrophilic polymer (chitosan) is used at **1% to 10%, preferably 1% to 3%.** (zein) is used at **0.5% to 15%, preferably 1% to 4%.**
- These ranges give the composite both water retention and mechanical strength.

Fabrication & Crosslinking

- The composite is stabilized using crosslinking agents like calcium chloride, ferric chloride, or zinc chloride.
- It can be fabricated by **freeze-drying at –20°C to –100°C** or by **3D printing**, ensuring porous structures for cell growth.

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