A Review of Vascular Networks for Self-Healing Applications

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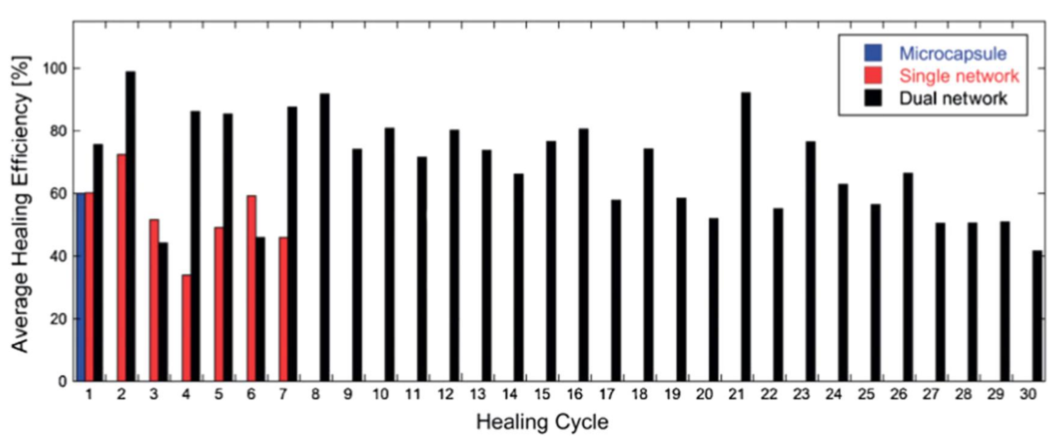
Purpose

Provide a comprehensive overview of the current progress and limitations of the design approaches, fabrication methods, healing mechanisms, and applications of embedded vascular networks for self-healing purposes.

Background

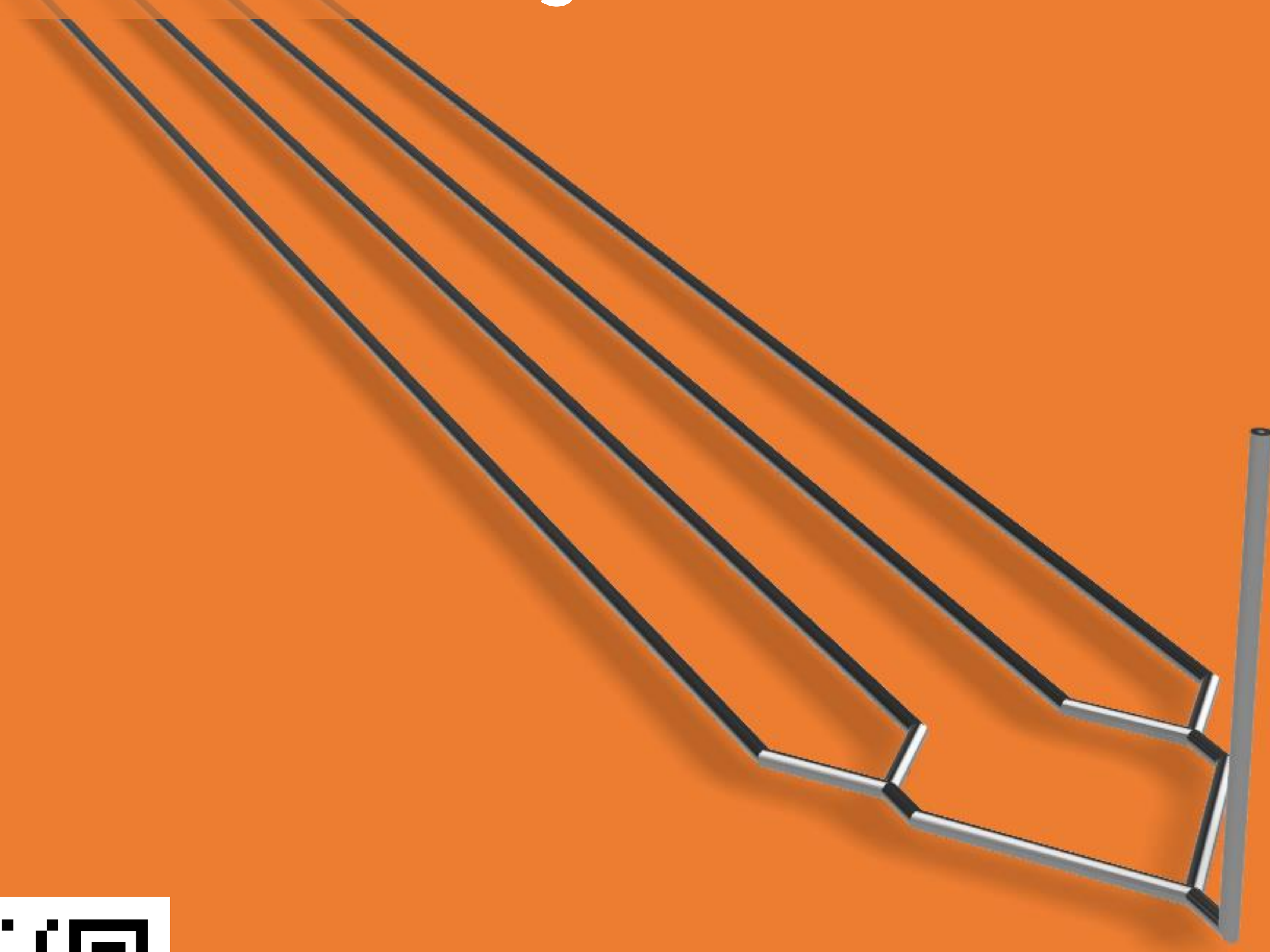
- Embedding a vascular network in a host can address varying magnitudes of damage and allow an indefinite replenishment of a healing agent, which are current limitations of intrinsic and capsule-based self-healing systems.
- These networks are demonstrated in polymer and composite materials, with fabrication methods including removal of sacrificial elements, soft lithography, electrospinning, and additive manufacturing (AM).



Conclusions

- While multiple healing cycles are possible, networks blockages are a major limitation for healing efficiency; further optimization is needed to reduce or eliminate them.
- Most fabrication techniques are limited to planar configurations; complex geometries can be realized with recent improvements made in AM.
- Scaling up requires further collaboration between chemists, material scientists, computer scientists, and additive manufacturing specialists.

A vascular network for self-healing materials can **reduce maintenance costs** and **increase durability**, with the advantage of being available for **multiple healing cycles** and capable of healing varying magnitudes of damage.



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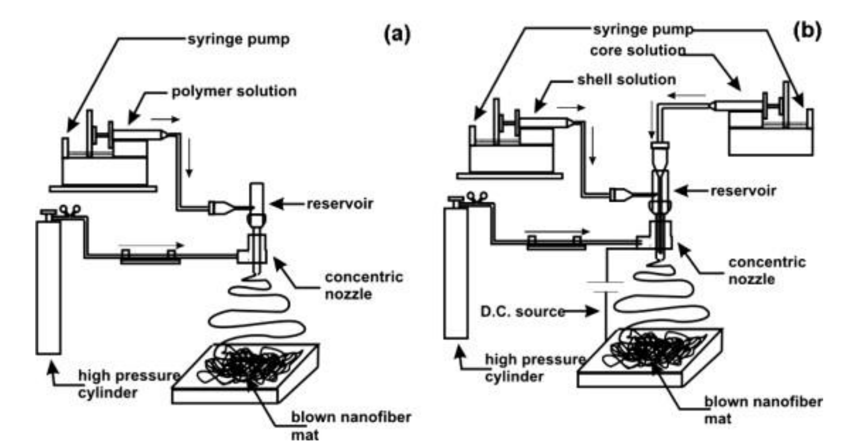
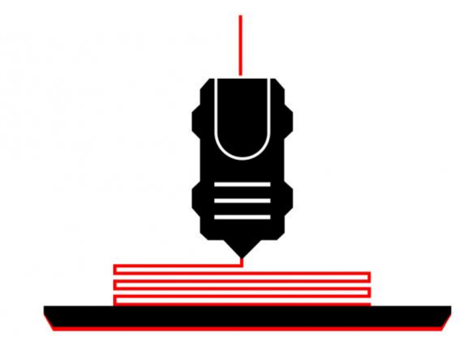
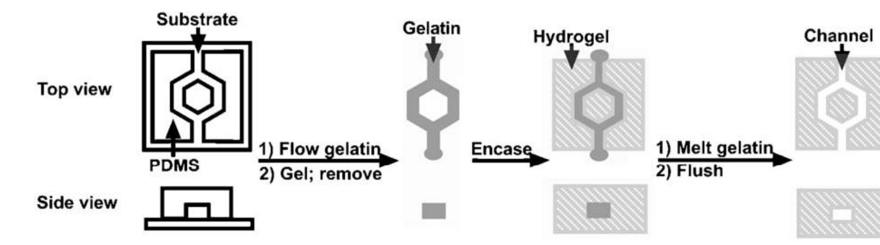
Solution blowing & electrospinning



Fused deposition modelling



Soft lithography



Constructal Law (Dr. Adrian Bejan) provides the basis for optimizing simple configurations and efficient design of flow networks, by maximizing flow access with minimizing resistance.

Murray's Law is nature's approach to network design, relating the radii of the parent and daughter branches a network that minimizes power required for fluid transport:

$$r_p^3 = r_{d1}^3 + r_{d2}^3$$

An evolutionary algorithm draws inspiration from Darwin's theory of evolution, where natural selection modifies subsequent generations for suitability to the environment.

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