RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 4, Issue 4, 2026

ADVANCED POLYMERIC MATERIALS FOR BURN WOUND HEALING: A COMPREHENSIVE REVIEW

Natasha Mukhtiar*[1], Muhammad Fahad Shamim[2], Sarmad Shams[3], Zeeshan Khatri[4], Binafsha Manzoor[5], Sehreen Moorat[6]

[1,2,3,6]Institute of Biomedical Engineering & Technology, LUMHS Jamshoro, Pakistan
[3]Biomedical Engineering Department, College of Engineering Imam Abdurrahman bin Faisal University Dammam, Kingdom of Saudi Arabia
[4]Department of Textile Engineering, MUET Jamshoro, Pakistan
[5]Medical Research Center, LUMHS Jamshoro, Pakistan

*[1]natasha.mukhtiar@lumhs.edu.pk

Corresponding Author: *
Natasha Mukhtiar

DOI: https://doi.org/10.5281/zenodo.19451739

Received	Accepted	Published
11 February 2026	23 March 2026	07 April 2026

ABSTRACT

Burn wounds shows complex healing challenge due to infection hazard, fluid loss, inflammation, and late tissue rejuvenation. Progressive wound dressings produced by polymeric biomaterials have arisen as effective solutions since they can preserve a moist environment, offer antimicrobial shield, support cell growth, and supply therapeutic agents in a precise manner. Both natural and synthetic polymers are extensively used to produce burn wound dressings, mostly in the form of nanofibers-based dressings produced by multiple techniques such as electrospinning. Natural polymers offer outstanding biocompatibility and bioactivity; however synthetic polymers deliver mechanical strength and controlled degradation. Polymer composite systems merge these benefits to produce ideal burn healing dressing. This review highlights main polymers used in burn wound healing, their physiochemical and biological properties, and their roles in enhancing tissue redevelopment and infection prevention.

Keywords: *Polymers, degradable and nondegradable materials, Electrospinning, Burn healing, polymeric patch, biocompatibility, Physiochemical properties.*

Introduction and Background

Burn injuries signify a significant global health problem, often important to extensive tissue destruction, scar, functional loss, and prolonged morbidity [1]. The multifaceted pathophysiological processes involved, containing infection risk, dehydration, and scarring, shows considerable therapeutic challenges [2] (2 zamani 2025). Conventional wound dressings regularly fall short in maintaining an optimal healing microenvironment and lack sufficient biocompatibility or antimicrobial properties [3]. Therefore, progressive wound care approaches gradually focus on polymeric biomaterials due to their customized physicochemical properties, biocompatibility, and facility to actively control wound healing [4]. These polymers provide mechanical support, control moisture, and supply therapeutic agents, so accelerating tissue redevelopment and purposeful recovery [5].

Polymers used in burn wound healing are typically categorized into natural and synthetic types, each impact different benefits and limits [6]. Natural polymers, familiar for their inherent biocompatibility, bioactivity, and structural similarity to the extracellular matrix (ECM), are frequently used in recreating medicine [7]. These polymers vigorously stimulate wound healing processes and help in tissue rebuilding [8]. In contrast, synthetic polymers deliver enhanced control over degradation, mechanical properties, and drug release kinetics, allowing for tunable applications [9].

Natural Polymers in Burn Wound Healing

Natural polymers are originated from biological sources and are greatly valued for their biocompatibility, biodegradability, and capability to mimic the natural ECM, which is essential for encouraging cell adhesion, proliferation, and tissue redevelopment [10]. The wound healing process includes complex collaborations between several factors, and natural polymers can modify these interfaces effectively [11].

Chitosan

Chitosan, derived from chitin, is widely used in burn wound dressings due to its distinctive properties. It shows inherent antimicrobial property, hemostatic capabilities, and promotes cellular proliferation and tissue redevelopment [12]. Chitosan's positive charge permits it to intermingle with negatively charged cell membranes, simplifying cellular processes critical for wound healing [13]. It also practices a protective barrier, reducing fluid loss and avoiding bacterial invasion [14]. Researches have shown that chitosan-based hydrogels can significantly accelerate burn wound healing by retaining a moist environment conducive to cell growth and relocation [15]. For example, a novel thin film merging chitosan, carboxymethyl cellulose, tannic acid, and beeswax has been expressed to increase wound healing applications [16]. Chitosan nanoparticles, mainly when combined into electrospun nanofibers with therapeutic agents, have proven enhanced antibacterial activity and cell growth elevation in progressive wound dressings [15].

Collagen

Collagen, the most abundant protein in the ECM, shows a crucial role in wound healing by providing mechanical support and signaling signs for cellular processes [17]. It stimulates fibroblast proliferation, angiogenesis, and re-epithelialization [18]. Collagen-based wound dressings increase the wound healing process and help in skin restoration [7]. Nanofiber frameworks prepared from collagen are mainly effective for skin regeneration and wound dressing applications due to their high surface area and structural similarity to native tissue [17]. Composite of synthetic polypeptides with collagen have also been examined for their wound healing features, presenting promising miscibility and physicochemical properties [18]. Moreover, merging collagen with mesenchymal stem cells (MSCs) within hydrogels has presented an accelerating effect on burn wound healing. [19].

Alginate

Alginate, a polysaccharide originated from brown algae, forms hydrogels upon interaction with exudates, forming a moist wound environment vital for healing [20].It shows superb biocompatibility, biodegradability, and hemostatic properties [10]. Alginate dressings are recognized for their great absorption capacity, building them appropriate for highly exuding wounds, and can be combined with other polymers like polyvinyl alcohol (PVA) to improve their biological physical, and mechanical properties [20].

Cellulose and Derivatives

Cellulose and its products, such as carboxymethyl cellulose, are extensively used in wound care due to their biocompatibility, low cost, and capability to absorb wound exudates [21]. They contribute to preserving a moist wound environment and avoiding bacterial adhesion. In spite of their extensive use, conventional cellulose-based dressings usually have limitations in supporting recreating healing and inhibiting infection [1].

Other Natural Polymers

Other natural polymers consist of silk hyaluronic acid, keratin, and exopolysaccharides from marine bacteria [22]. Hyaluronic acid is important for tissue hydration and cellular migration. .Keratin, a protein, offer cell attachment and proliferation [23]. Silk has shown potential in film development for wound healing, mainly when amplified with agents like honey and recombinant human epidermal growth factor (rhEGF) [24]. Bacterial exopolysaccharides, such as those produced by Halomonas malpeensis, are developing as biopolymers with major potential for burn wound healing due to their useful physicochemical and biological properties [25].

Synthetic Polymers in Burn Wound Healing
Synthetic polymers provide significant benefits in terms of accurate control over their mechanical, structural, and degradation properties, which can be custom-made for particular wound healing applications [26]10 . This custom made property allows for the development of progressive wound dressings with improved functionality [9].

Polyvinyl Alcohol (PVA)
PVA is a water-soluble synthetic polymer commonly used in hydrogel formulations for wound dressings due to its biocompatibility and capability to produce form stable hydrogels [27]. PVA based hydrogels can produce a moist environment, stimulate autolytic debridement, and assist cell migration [28]. Composite PVA with natural polymers like alginate can additionally increase the mechanical strength and biological performance of the dressings. PVA is employed in electrospun nanofibers, in some applications in combination with other polymers like polycaprolactone (PCL), to produce advanced wound dressings with growth-promoting and antimicrobial properties [29].

Polycaprolactone (PCL)
PCL is a biodegradable polyester recognized for its outstanding mechanical properties and biocompatibility [15]. It is broadly used in electrospun nanofiber based scaffolds for tissue engineering and wound healing applications, offering a structural framework that mimics the ECM [30]. PCL can be merged with other polymers and active agents to produce multifunctional dressings. Such as , PCL nanofibers fused with Centella asiatica extract and silver nanoparticles (AgNPs) have proven enhanced burn wound healing ability and broad-spectrum antibacterial activity [31]. Moreover, PCL membranes treated with chitosan oligosaccharides and AgNPs have been produced for skin wound care, proposing antibacterial properties and stimulating healing [32].

Poly (lactic-co-glycolic acid) (PLGA)
PLGA is a copolymer of lactic acid and glycolic acid, popular for its biodegradability and biocompatibility. Its degradation rate can be specifically controlled by modifying the ratio of lactic to glycolic acid, creating it appropriate for various drug delivery and tissue engineering uses. PLGA-based materials help to form the scaffolds for cell growth and proliferation, contributing to wound healing and tissue redevelopment [28].

Polyurethanes
Polyurethanes are useful synthetic polymers used in wound dressings because of their custom-made breathability, mechanical properties, and obstruction function. They can produce hydrogels, foams, and films, adjusting to different types of wounds. They are offering marvelous biological properties, old polyurethane dressings might lack the vibrant adaptability required for complex clinical requirements, dynamic research into supplementary functionalized alternatives [33].

Table:1 Different types of polymers and their properties and advantages [34] [27, 35]

Polymer	Type	Key Properties	Benefits in Burn Healing	Limitations
Chitosan	Natural (biopolymer)	Antibacterial, biodegradable, hemostatic	Prevents infection, promotes tissue regeneration	Poor mechanical strength alone
Alginate	Natural	Highly absorbent, gel-forming	Maintains moist environment, absorbs exudate	Low mechanical stability
Collagen	Natural	Biocompatible, promotes cell adhesion	Enhances tissue regeneration and skin formation	Expensive, weak mechanical strength
Gelatin	Natural (collagen derivative)	Biodegradable, hydrophilic	Supports cell growth and wound hydration	Rapid degradation
Hyaluronic Acid	Natural	Hydrating, promotes cell migration	Accelerates healing and reduces inflammation	Poor mechanical strength
Silk Fibroin	Natural protein	Strong, biocompatible, breathable	Supports tissue repair and oxygen permeability	Requires processing
Cellulose (Bacterial/Plant)	Natural	High moisture retention, biocompatible	Maintains moist wound environment	Limited antibacterial activity
Polyvinyl Alcohol (PVA)	Synthetic	Hydrophilic, flexible, film-forming	Provides moisture balance and mechanical strength	Needs blending for bioactivity
Polycaprolactone (PCL)	Synthetic	Biodegradable, strong mechanical properties	Provides structural support and controlled drug release	Slow degradation
Polylactic Acid (PLA)	Synthetic	Biocompatible, biodegradable	Supports tissue regeneration	Brittle when used alone
Polyethylene Glycol (PEG)	Synthetic	Hydrophilic, non-toxic	Enhances hydration and drug delivery	Weak mechanical strength
Polyurethane (PU)	Synthetic	Elastic, breathable, durable	Protects wound and allows gas exchange	Non-biodegradable types exist

Hydrogels in Burn Wound Healing

Hydrogels, either natural, synthetic, or hybrid, diversified class of polymeric materials commonly applied in burn wound healing [28]. Their 3D cross-linked polymer linkages have great water retention, generating a moist healing environment that encourages cell immigration, proliferation [36]. This moist environment is crucial for preventing dehydration, reducing scar formation, and supporting the natural healing force [28].

Hydrogels can be loaded with different therapeutic drugs, comprising antimicrobials, growth factors, and anti-inflammatory agents, allowing for precise and sustained discharge at the wound site [37]. This targeted delivery improves therapeutic efficiency and reduces local and systemic side effects. For example, chitosan hydrogels can combine antimicrobial agents, addressing the serious challenge of infection in burn wounds [38].

Nanomaterials and Advanced Inventions

The mixture of polymers with nanotechnology has focused to the expansion of advanced wound dressings with better properties [37]. Polymeric nanoparticles and electrospun nanofibers offer greater surface area-to-volume ratios, permitting operative drug loading and precise release [39]. Nanofiber scaffolds, made up of dissimilar natural and synthetic polymers, mimic the native ECM, offering the premium environment for cellular dispersion and tissue redevelopment [40]. Electrospinning is a commonly used technique to fabricate polymeric nanofibers, often merged with bioactive compounds to accelerate wound healing [39]. Samples include PCL/PVA electrospun nanofibers with chitosan-LL37 and chitosan-VEGF nanoparticles for improved antibacterial and cell growth-promoting properties. Recreating protein nanoscaffolds, such as alpha-lactalbumin (ALA) founded electrospun nanofibrous scaffolds, have revealed better efficacy in burn wound healing compared to former protein scaffolds [41]. The wound healing progression is complex, including hemostasis, inflammation, proliferation, and tissue renovation [42]. Burn wounds existing a unique experiment due to the damage of skin layers and adnexal structures, possibly leading to deep partial-thickness or full-thickness wounds somewhere natural restoration is compromised or terrible. These deeper burns often need surgical interpolation, such as excision and skin grafting, to attain closing and inhibit extreme scarring and contractures [43]. In a burn wound, where tissue is damaged but possibly salvageable, is a dangerous target for polymeric mediations aimed at avoiding more tissue loss and encouraging recovery [44].

The progress of pioneering polymeric materials is important for addressing the challenges in burn wound administration [45]. These materials not only deliver physical safeguard but also actively contribute in controlling the biological processes of healing, involvement a promising avenue for successful results for burn patients [46].

The efficiency of polymers in burn wound healing is recognized to a blend of important properties that report the complex and energetic biological process of tissue repair, with hemostasis, inflammation, proliferation, and tissue restoration [22]. These properties allow polymers to produce an ideal microenvironment for healing, shield the wound, and deliver therapeutic agents efficiently.

Physiochemical and Biological Properties of Polymers

One of the most important properties is biocompatibility, which confirms that the polymeric material does not cause adverse immune responses or cytotoxicity in the human body [38] . Biocompatible polymers, mainly natural ones, mimic the extracellular matrix (ECM) and assist cellular processes such as adhesion, cell division and proliferation, which are crucial for tissue redevelopment [5]. This property is essential for stimulating the integration of the dressing with the nearby tissues and reducing inflammation.

Biodegradability is an additional vigorous characteristic, allowing the polymer to naturally degrade and be absorbed by the body over time without needing removal, thus decreasing patient discomfort and potential trauma to the healing wound. The degradation rate can be regulated in synthetic polymers like poly(lactic-co-glycolic acid) (PLGA) by altering their composition, which is useful for regulating the release of integrated drugs and matching the rate of tissue restoration [28].

The capability to maintain a moist wound environment is dominant for ideal burn wound healing. Polymers, specifically those formulated as hydrogels, attain this due to their greater water content and hydrophilic nature [47]. A moist environment inhibits wound desiccation, stimulates cell migration, enables autolytic debridement, and decreases scar formation.

Antimicrobial properties are necessary for inhibiting and managing infections, which are a key problems in burn wounds [48]. Some polymers, such as chitosan, keep intrinsic antibacterial activity. Furthermore, polymers can be planned to provide antibacterial agents, like silver nanoparticles (AgNPs) or antimicrobial peptides (e.g., LL-37), to the wound site, offering persistent security against bacterial colonization [32]. For instance, studies have proven that electrospun poly(ε-caprolactone) (PCL) membranes comprising AgNPs and coated with chitosan oligosaccharides display durable antibacterial activity against both Gram-positive and Gram-negative bacteria [49].

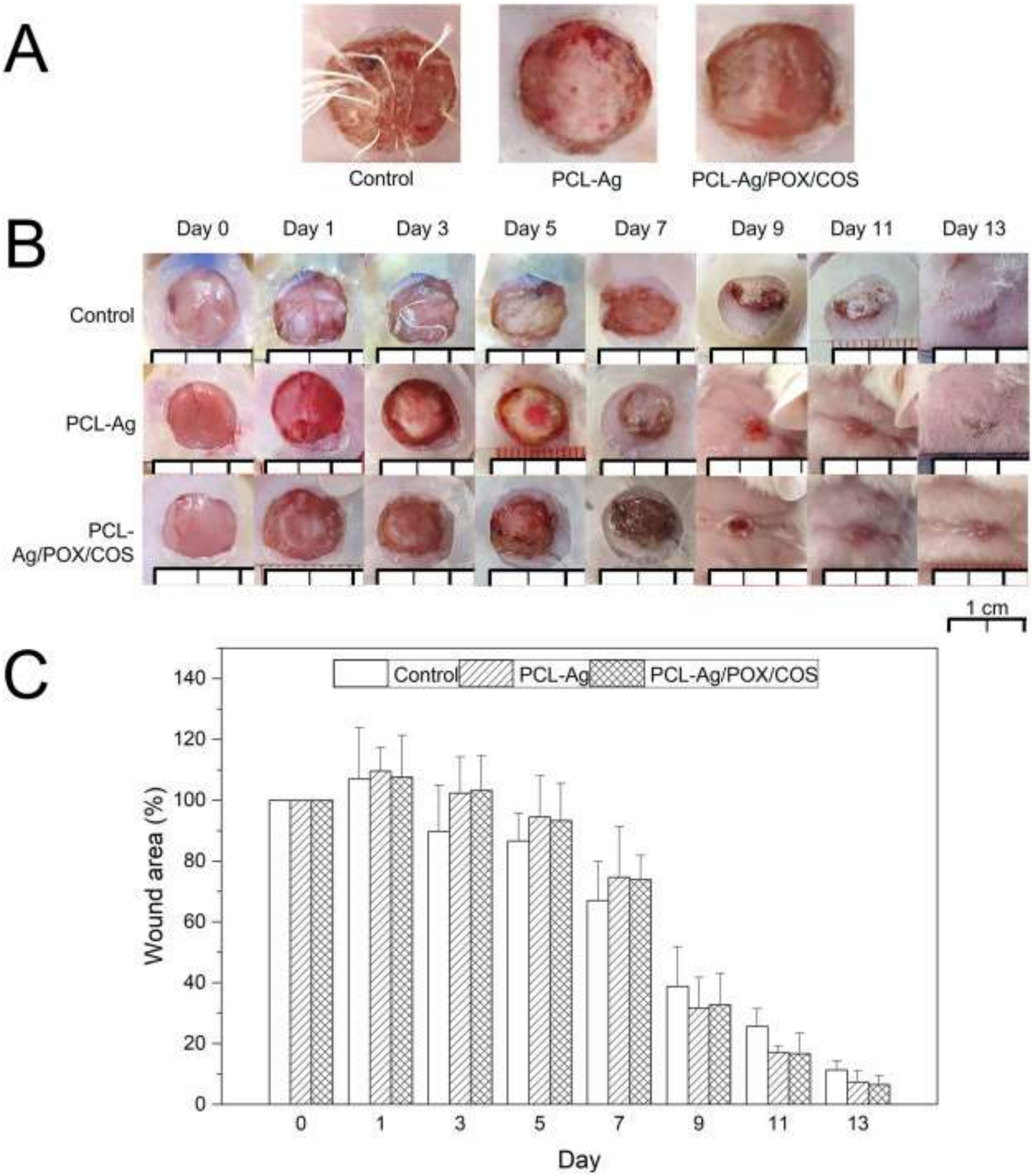

Fig: 3 Multilayer membrane (PCL-Ag/POX/COS)***Source: [19].***

Mechanical properties, containing elasticity, tensile strength, and flexibility, are critical to deliver structural support to the healing tissue and imitate to uneven wound surfaces [19]. Polymers can be fabricated into many forms, such as, nanofibers, films and foams, and, to offer suitable mechanical stability while permitting for association without causing further damage. PCL nanofibers are valued for their exceptional structural properties and ability to mimic the ECM, proposing a robust scaffold for tissue redevelopment [50].

The proficiency for precise drug release is important advantage of polymeric systems. Polymers can act as transport vehicles for broad range of therapeutic drugs, comprising growth factors, anti-inflammatory agents, and antibiotics, approving their continuous and localized presence at the wound site. This concise targeted transfer of drug can increase therapeutic efficiency and reduce systemic side effects. Nanotechnology, in specific, experts for the encapsulation of bioactive within polymeric nanoparticles and nanofibers, improving their strength and bioavailability [12].

Porous structure and abundant surface area, mainly in nanofibrous scaffolds produced through methods like electrospinning, enable cell infiltration, nutrient interchange, and waste elimination, systematically mimicking the innate skin structure [51]. This may stimulate effective cellular colonization and neo-tissue development. Recreating protein nano-scaffolds, made from alpha-lactalbumin (ALA), have exhibited promising results in stimulating wound recovery by providing an ideal environment for cellular remodeling [52].

The Hemostatic properties are useful, mostly in severe burn wounds where bleeding can be a concern. Polymers like chitosan keep hemostatic capabilities, facilitating in blood clotting and stopping extreme blood loss [53].

Table: 2 Review matrix of different Polymers used in wound dressings

Polymer	Type	Key Properties	Advantages in Burn Healing	Limitations	Example Applications	Key References
Chitosan	Natural polysaccharide	Biocompatible, biodegradable, antibacterial, hemostatic	Prevents infection, promotes cell proliferation, accelerates healing	Poor electrospinnability alone, weak mechanical strength	Nanofibers, hydrogels, films	[54]
Alginate	Natural polysaccharide	High absorbency, gel-forming, moist environment	Excellent exudate management, soothing effect	Low mechanical strength	Calcium alginate dressings	[52]
Gelatin	Natural protein	Biocompatible, promotes cell adhesion	Enhances fibroblast growth & tissue regeneration	Rapid degradation, weak stability	Electrospun scaffolds	[55]

Collagen	Natural protein	ECM-mimicking, promotes cell migration	Accelerates tissue regeneration & granulation	Expensive, low stability	Skin substitutes, scaffolds	[18]
Hyaluronic Acid	Natural glycosaminoglycan	Hydrating, anti-inflammatory	Promotes angiogenesis & scar reduction	Fast degradation	Hydrogels, bioactive dressings	[56]
Silk Fibroin	Natural protein	High mechanical strength, biocompatible	Supports cell attachment & regeneration	Complex processing	Nanofibers, films	[57]
Polyvinyl Alcohol (PVA)	Synthetic polymer	Hydrophilic, flexible, good film-forming	Enhances mechanical strength & moisture retention	Lacks intrinsic antimicrobial activity	Electrospun nanofibers, hydrogels	[58]
Polycaprolactone (PCL)	Synthetic polymer	Biodegradable, strong mechanical support	Provides structural stability & slow degradation	Hydrophobic surface	Nanofibrous scaffolds	[59]
Polyethylene Glycol (PEG)	Synthetic polymer	Hydrophilic, non-toxic	Improves hydration & drug delivery	Poor mechanical strength alone	Hydrogel systems	[50]
Polylactic Acid (PLA)	Synthetic polymer	Biodegradable, good strength	Controlled drug release & support	Brittle & hydrophobic	Electrospun fibers	[60]

Conclusion

Burn wound administration continues to progress with the improvement of progressive polymer-based dressings intended to enhance infection control, rapid healing, and minimize scarring. Evidence from recent studies (2020–2023) proves that natural polymers such as chitosan, alginate, collagen, silk, fibroin, and gelatin stimulate cellular attachment, angiogenesis, and extracellular matrix (ECM) rejuvenation, making them more suitable for natural healing. In contrast, synthetic polymers like polylactic acid (PLA), Polycaprolactone (PCL), polyvinyl alcohol (PVA), and offer more structural stability, mechanical strength, and precise degradation, which are important for preserving dressing reliability and secondary tissue repair. Hydrogel systems have developed as predominantly effective due to their greater water retention, moisture balance ability, and capability to transport therapeutic drugs in a controlled manner, making an ideal environment for burn wound healing.

Recent progresses highlight multifunctional and hybrid composite systems like chitosan PCL hydrogels, PLA Gelatin-based nanofibers, and polymer-composite blend electrospun scaffold that integrate biological activity with mechanical strength. These hybrid systems mimic the inherent ECM, boost re-epithelialization, and provide antibacterial and anti-inflammatory effects. The custom-made and adaptability of polymers allow for the production of customized dressings that can deliberately adjust to altering wound environment 2027. This contains stimuli-responsive materials that can discharge therapeutics based on definite environmental cues, or materials that can modify their properties as the wound heals 2820. The main property consists of flexibility which represents a new periphery in wound maintenance. The significant properties of polymers for burn wound injuries include custom-made physiochemical and biological properties such as biodegradability, structural strength, biocompatibility, the ability to balance the moist environment, antibacterial activity, suitable mechanical properties, precise drug release facilities, and a spongy structure beneficial to cell proliferation and tissue remodeling.

Although substantial advancement, challenges remain in optimizing mechanical properties, degradation rates, large-scale manufacturing, and clinical transformation. Upcoming research should emphasis on smart bioactive dressings, stimuli-responsive hydrogels, and low cost manufacturing methods to improve availability and therapeutic products. Generally, polymeric burn wound dressings signify a promising and fast advancing approach for advance burn care management and hazel free patient recovery within short time frame. The characteristics features in burn wound dressing collectively help to the improve the phases of healing and provide the next generation wound care management to the healthcare industry.

References

[1] A. N. Jha, V. R. Gaikwad, A. K. Gupta, and S. Singh, "Bioinspired polymeric constructs in management of burn wounds: current trends and future," *Polymer Bulletin*, vol. 83, 2025/12/4 2025.

[2] S. Zamani, A. Ehterami, A. Vaez, M. Naeiji, H. Maghsoodifar, S. A. H. Sadeghi douki, *et al.*, "Natural and synthetic polymers in burn wound healing," *Journal of Biomaterials Science, Polymer Edition*, vol. 37, pp. 118-183, 2025/6/30 2025.

[3] D. Tripathy, S. R. Rout, I. Saha, J. Halder, T. K. Rajwar, V. K. Rai, *et al.*, "Synthetic Polymer-Based Interventions in Wound Healing: A Clinical Perspective on their Efficacy and Limitations," *Current Pharmaceutical Design*, vol. 32, 2025/10/23 2025.

[4] P. Das, S. Manna, S. Roy, S. K. Nandi, and P. Basak, "Polymeric biomaterials-based tissue engineering for wound healing: a systemic review," *Burns & Trauma*, vol. 11, 2023/1/1 2023.

[5] S. Prete, M. Dattilo, F. Patitucci, G. Pezzi, O. I. Parisi, and F. Puoci, "Natural and Synthetic Polymeric Biomaterials for Application in Wound Management," *Journal of Functional Biomaterials*, vol. 14, p. 455, 2023/9/3 2023.

[6] A. S. Bhavikatti, S. C. Furtado, P. Mallya, and B. B.V, "A review of natural polymer based biomaterials for wound care: addressing challenges and future perspectives," *Journal of Biomaterials Science, Polymer Edition*, vol. 37, pp. 93-117, 2025/6/27 2025.

[7] M. Shahzadi, T. Hassan, and S. Saeed, "Application of Natural Polymers in Wound Dressings," *Pakistan Journal of Medical and Health Sciences*, vol. 16, pp. 1-2, 2022/10/30 2022.

[8] T. A. Debele and W.-P. Su, "Polysaccharide and protein-based functional wound dressing materials and applications," *International Journal of Polymeric Materials and Polymeric Biomaterials*, vol. 71, pp. 87-108, 2020/9/8 2020.

[9] R. Xu and Y. Fang, "Recent Advances in Biodegradable and Biocompatible Synthetic Polymers Used in Skin Wound Healing," vol. 16, Aug 3 2023.

[10] S. Bhattacharjee, D. D. Sarkar, D. R. Dayaramani, D. S. A. Kumar, R. Bhattacharjee, and S. Bhattacharjee, "A Technical Overview: Polymers for Wounds and Burns Dressing as Hydrogel Drug Delivery System," *International Journal of Pharmaceutical Sciences Review and Research,* pp. 198-207, 2022/5/15 2022.

[11] N. Jangra, A. Singla, V. Puri, D. Dheer, H. Chopra, T. Malik*, et al.*, "Herbal bioactive-loaded biopolymeric formulations for wound healing applications," *RSC Advances,* vol. 15, pp. 12402-12442, 2025 2025.

[12] Q. Bai, C. Zheng, W. Chen, N. Sun, Q. Gao, J. Liu*, et al.*, "Current challenges and future applications of antibacterial nanomaterials and chitosan hydrogel in burn wound healing," *Materials Advances,* vol. 3, pp. 6707-6727, 2022 2022.

[13] H. Barkat, M. Abuzar, Y. I. Asiri, M. Z. Hassan, A. A. Alanezi, H. Hadi*, et al.*, "Chitosan-based nanotherapeutics in burn wound management: Clinical insights and healing potential," *International Journal of Biological Macromolecules,* vol. 328, p. 147639, 2025/11 2025.

[14] M. Ali, S. Ullah, S. Ullah, M. Shakeel, T. Afsar, F. M. Husain*, et al.*, "Innovative biopolymers composite based thin film for wound healing applications," *Scientific Reports,* vol. 14, 2024/11/9 2024.

[15] S. Fahimirad, M. Khaki, E. Ghaznavi-Rad, and H. Abtahi, "Investigation of a novel bilayered PCL/PVA electrospun nanofiber incorporated Chitosan-LL37 and Chitosan-VEGF nanoparticles as an advanced antibacterial cell growth-promoting wound dressing," *International Journal of Pharmaceutics,* vol. 661, p. 124341, 2024/8 2024.

[16] u. Salwa Fajriati Maulida Mudakir, u. Dina Mulyanti, and u. Sani Ega Priani, "Literatur Review Sediaan Hidrogel Mengandung Kitosan Untuk Penyembuhan Luka Bakar," *Bandung Conference Series: Pharmacy,* vol. 4, pp. 416-425, 2024/8/13 2024.

[17] Z. Mbese, S. Alven, and B. A. Aderibigbe, "Collagen-Based Nanofibers for Skin Regeneration and Wound Dressing Applications," *Polymers,* vol. 13, p. 4368, 2021/12/13 2021.

[18] D. Kathyayani, B. Mahesh, D. Channe Gowda, A. Sionkowska, and S. Veeranna, "Investigation of miscibiliy and physicochemical properties of synthetic polypeptide with collagen blends and their wound healing characteristics," *International Journal of Biological Macromolecules,* vol. 246, p. 125704, 2023/8 2023.

[19] M. Vkoukaeyan, S. Nasim Mirbahari, and N. Amini, "Burn wound healing effect of mesenchymal stem cells seeded into collagen-chitosan in animal model," *Journal of Biological Studies,* vol. 5, pp. 363-377, 2022/9/21 2022.

[20] M. M. Saraiva, M. d. S. Campelo, J. F. Câmara Neto, A. B. N. Lima, G. d. A. Silva, A. T. d. F. F. Dias*, et al.*, "Alginate/polyvinyl alcohol films for wound healing: Advantages and challenges," *Journal of Biomedical Materials Research Part B: Applied Biomaterials,* vol. 111, pp. 220-233, 2022/8/12 2022.

[21] A. Yadav, R. R. Ujjwal, S. Tripathi, and S. T. V. S. Krishna, "Polymer-based Nanotherapeutics for Burn Wounds," *Current Pharmaceutical Biotechnology,* vol. 23, pp. 1460-1482, 2022/10 2022.

[22] M. H. Kazemi, S. Sajadimajd, and Z. G. Karaji, "In vitro investigation of wound healing performance of PVA/chitosan/silk electrospun mat loaded with deferoxamine and ciprofloxacin," *International Journal of Biological Macromolecules,* vol. 253, p. 126602, 2023.

[23] A. Nagaraj, Y. Subramaniyan, S. Surya, and P. D. Rekha, "Burn Wound Healing Abilities of a Uronic Acid Containing Exopolysaccharide Produced by the Marine Bacterium Halomonas malpeensis

YU-PRIM-29 T," *Applied Biochemistry and Biotechnology,* vol. 196, pp. 8190-8213, 2024/5/3 2024.

[24] S. Nachiappan, L. Amanuel, T. Agazie, and S. Bihonegn, "Development and characterization of silk films for burn wound healing," *Research Journal of Textile and Apparel,* vol. 24, pp. 131-146, 2020/4/10 2020.

[25] M. Elsamman, O. M. El-borady, M. M. Nasr, Z. Al-Amgad, and A. A. Metwally, "Development of propolis, hyaluronic acid, and vitamin K nano-emulsion for the treatment of second-degree burns in albino rats," *BMC Complementary Medicine and Therapies,* vol. 24, 2024/2/16 2024.

[26] N. Kazemi, M. Javad Mahalati, Y. Kaviani, M. H. Al-Musawi, J. Varshosaz, S. Soleymani Eil Bakhtiari, *et al.*, "Core-shell nanofibers containing L-arginine stimulates angiogenesis and full thickness dermal wound repair," *International Journal of Pharmaceutics,* vol. 653, p. 123931, 2024/3 2024.

[27] E. Hadipour-Goudarzi, N. Hemmatinejad, and M. A. Shokrgozar, "Fabrication and DOE optimization of electrospun chitosan/gelatin/PVA nanofibers for skin tissue engineering," *Macromolecular Materials and Engineering,* vol. 308, p. 2200562, 2023.

[28] D. Jain, A. Syed, and D. Rajamanickam, "Advances in Hydrogel-Based Wound Dressings: Enhancing Tissue Regeneration and Healing Through Polymer Innovations," *Journal of Pharmacological and Pharmaceutical Research,* vol. 2, p. 60, 2025 2025.

[29] A. S. Arampatzis, K. N. Kontogiannopoulos, K. Theodoridis, E. Aggelidou, A. Rat, A. Willems, *et al.*, "Electrospun wound dressings containing bioactive natural products: physico-chemical characterization and biological assessment," *Biomater Res,* vol. 25, p. 23, Jul 16 2021.

[30] O. Bozkaya, E. Bozkaya, H. Ekici, M. E. Alçığır, Y. Şahin, N. Aytuna Çerçi, *et al.*, "Evaluation of Burn Wound Healing Efficacy and Biocompatibility of <i>Centella asiatica</i> Mediated Synthesised AgNPs Loaded Hybrid Nanofiber Scaffold: In Vitro and In Vivo Studies," *Macromolecular Materials and Engineering,* vol. 309, 2024/8/18 2024.

[31] A. L. Alfalluji, Q. S. Kadhim, and A. A. Mahdi, "Electrospun poly (ε-caprolactone)/silver nanoparticle nanofibrous scaffolds with antibacterial activity for wound-dressing applications," *RSC advances,* vol. 15, pp. 37899-37907, 2025.

[32] T.-N. Tang, T. H.-A. Nguyen, C. M. Tran, V. K. Doan, N. T.-T. Nguyen, B. T. Vu, *et al.*, "Fabrication of silver nanoparticle-containing electrospun polycaprolactone membrane coated with chitosan oligosaccharides for skin wound care," *Journal of Science: Advanced Materials and Devices,* vol. 8, p. 100582, 2023/9 2023.

[33] W. Liang, N. Ni, Y. Huang, and C. Lin, "An Advanced Review: Polyurethane-Related Dressings for Skin Wound Repair," *Polymers,* vol. 15, p. 4301, 2023/11/1 2023.

[34] M. Dash, F. Chiellini, R. M. Ottenbrite, and E. Chiellini, "Chitosan—A versatile semi-synthetic polymer in biomedical applications," *Progress in Polymer Science,* vol. 36, pp. 981-1014, 2011/08/01/ 2011.

[35] A. Shamloo, Z. Aghababaie, H. Afjoul, M. Jami, M. R. Bidgoli, M. Vossoughi, *et al.*, "Fabrication and evaluation of chitosan/gelatin/PVA hydrogel incorporating honey for wound healing applications: An in vitro, in vivo study," *International Journal of Pharmaceutics,* vol. 592, p. 120068, 2021/01/05/ 2021.

[36] K. T. Mutore, R. Koduri, N. Alatrash, and V. Nomellini, "THE USE OF POLOXAMER 188 IN BURN INJURY TREATMENT: A SYSTEMATIC

LITERATURE REVIEW," *Shock*, vol. 62, pp. 461-469, 2024/8/14 2024.

[37] A. Ullah, M. Ullah, G.-J. Lee, and S. I. Lim, "A review of recent advances in nanotechnology for the delivery of therapeutics in wound healing," *Journal of Pharmaceutical Investigation*, vol. 55, pp. 33-54, 2024/8/19 2024.

[38] R. Koliqi, V. Uskokovic, P. B. Selmani, A. D. Grapci, and C. Mahapatra, "Polymeric Nanoparticles for Wound Healing," *Pharmaceutical Nanotechnology*, vol. 13, pp. 775-793, 2025/8 2025.

[39] N. Palani, P. Vijayakumar, P. Monisha, S. Ayyadurai, and S. Rajadesingu, "Electrospun nanofibers synthesized from polymers incorporated with bioactive compounds for wound healing," *Journal of Nanobiotechnology*, vol. 22, 2024/4/27 2024.

[40] L. Si, X. Guo, H. Bera, Y. Chen, F. Xiu, P. Liu, *et al.*, "Unleashing the healing potential: Exploring next-generation regenerative protein nanoscaffolds for burn wound recovery," *Asian Journal of Pharmaceutical Sciences*, vol. 18, p. 100856, 2023/11 2023.

[41] A. T. Yayehrad, E. A. Siraj, M. Matsabisa, and G. Birhanu, "3D printed drug loaded nanomaterials for wound healing applications," *Regen Ther*, vol. 24, pp. 361-376, Dec 2023.

[42] A. Noor, A. Afzal, R. Masood, Z. Khaliq, S. Ahmad, F. Ahmad, *et al.*, "Dressings for burn wound: a review," *Journal of Materials Science*, vol. 57, pp. 6536-6572, 2022/3 2022.

[43] Y. Chen, M. Chai, C. Xuan, J. Lin, H. Yang, C. Li, *et al.*, "Tuning the properties of surgical polymeric materials for improved soft-tissue wound closure and healing," *Progress in Materials Science*, vol. 143, p. 101249, 2024/6 2024.

[44] P. Sanjarnia, M. L. Picchio, A. N. Polegre Solis, K. Schuhladen, P. M. Fliss, N. Politakos, *et al.*, "Bringing innovative wound care polymer materials to the market: Challenges, developments, and new trends," *Advanced Drug Delivery Reviews*, vol. 207, p. 115217, 2024/4 2024.

[45] C. Oliveira, D. Sousa, J. A. Teixeira, P. Ferreira-Santos, and C. M. Botelho, "Polymeric biomaterials for wound healing," *Front Bioeng Biotechnol*, vol. 11, p. 1136077, 2023.

[46] G. Orive and M. F. Desimone, "Biopolymers Take Center Stage in Wound Healing Advancements," *Pharmaceutics*, vol. 16, p. 755, 2024/6/3 2024.

[47] S. Zamani, A. Ehterami, A. Vaez, M. Naeiji, H. Maghsoodifar, S. A. H. Sadeghi douki, *et al.*, "Natural and synthetic polymers in burn wound healing," *Journal of Biomaterials Science, Polymer Edition*, vol. 37, pp. 118-183, 2026/01/02 2026.

[48] P. Jayabal, V. Kannan Sampathkumar, A. Vinothkumar, S. Mathapati, B. Pannerselvam, S. Achiraman, *et al.*, "Fabrication of a Chitosan-Based Wound Dressing Patch for Enhanced Antimicrobial, Hemostatic, and Wound Healing Application," *ACS Applied Bio Materials*, vol. 6, pp. 615-627, 2023/02/20 2023.

[49] S. Alven and S. Peter, "Polymer-Based Wound Dressing Materials Loaded with Bioactive Agents: Potential Materials for the Treatment of Diabetic Wounds," vol. 14, Feb 14 2022.

[50] D. I. Sánchez-Machado, A. Maldonado-Cabrera, J. López-Cervantes, B. Maldonado-Cabrera, and A. F. Chávez-Almanza, "Therapeutic effects of electrospun chitosan nanofibers on animal skin wounds: A systematic review and meta-analysis," *Int J Pharm X*, vol. 5, p. 100175, Dec 2023.

[51] S.-H. Ji and J.-S. Yun, "Highly Porous-Cellulose-Acetate-Nanofiber Filters Fabricated by Nonsolvent-Induced Phase Separation during Electrospinning for PM2.5 Capture," *Nanomaterials*, vol. 12, p. 404, 2022.

[52] M. Valadi, M. Doostan, K. Khoshnevisan, M. Doostan, and H. Maleki, "Enhanced healing of burn wounds by multifunctional alginate-chitosan hydrogel enclosing silymarin and zinc oxide nanoparticles," *Burns,* vol. 50, pp. 2029-2044, 2024/11/01/ 2024.

[53] S. Li, W. Pan, M. Zhang, K. Song, Z. Zhou, Q. Zhao, *et al.*, "Chitosan-Based Dressing Materials for Burn Wound Healing," vol. 17, Jun 13 2025.

[54] M. Ansari and A. Darvishi, "A review of the current state of natural biomaterials in wound healing applications," *Frontiers in Bioengineering and Biotechnology,* vol. Volume 12 - 2024, 2024-March-27 2024.

[55] Y. Shi, H. Zhang, X. Zhang, Z. Chen, D. Zhao, and J. Ma, "A comparative study of two porous sponge scaffolds prepared by collagen derived from porcine skin and fish scales as burn wound dressings in a rabbit model," *Regenerative Biomaterials,* vol. 7, pp. 63-70, 2020.

[56] V. Gounden and M. Singh, "Hydrogels and Wound Healing: Current and Future Prospects," vol. 10, Jan 5 2024.

[57] Y. Guan, F. Sun, X. Zhang, Z. Peng, B. Jiang, M. Liang, *et al.*, "Silk fibroin hydrogel promote burn wound healing through regulating TLN1 expression and affecting cell adhesion and migration," *J Mater Sci Mater Med,* vol. 31, p. 48, May 13 2020.

[58] Y. Yang, S. Ma, A. Li, G. Xia, M. Li, C. Ding, *et al.*, "Antibacterial and antioxidant phlorizin-loaded nanofiber film effectively promotes the healing of burn wounds," *Frontiers in Bioengineering and Biotechnology,* vol. Volume 12 - 2024, 2024-August-05 2024.

[59] W. Zeng, N. M. Cheng, X. Liang, H. Hu, F. Luo, J. Jin, *et al.*, "Electrospun polycaprolactone nanofibrous membranes loaded with baicalin for antibacterial wound dressing," *Sci Rep,* vol. 12, p. 10900, Jun 28 2022.

[60] M. Moayedi, T. Ahmadi, V. Nekouie, M. T. Dehaghani, S. Shojaei, S. Z. Benisi, *et al.*, "Preparation and assessment of polylactic acid-curcumin nanofibrous wound dressing containing silver nanoparticles for burn wound treatment," *Burns,* vol. 51, p. 107442, 2025/05/01/ 2025.