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THIRD GENERATION MATERIALS FOR WOUND DRESSINGS

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ABSTRACT: An ideal wound Dressing need to be redefined based on the nature of wound and wound classifications. Since generations, wound have been defined as self-healing process, but chronic wounds and other wound requires handling and care from different parameters like moist conditions, biocompatibility, microbial infection to mention a few. Traditional methods have been continuously worked upon to deliver better products. Starting from simple gauze dressings in 1900's to bioactive dressings till today have been worked upon. Bioactive dressings based on different materials sodium alginate, chitosan, hydrocolloid, iodine has been covered in this review. Based on wounds different classifications of type of wounds, correlation of wounds with wound dressing have also been focussed upon. This has led to development of interactive dressings which are further developed as per wound requirement viz. semipermeable and hydrogel dressings. Efforts are in process to develop superabsorbing and bioactive material for critical wound care. The conventional primary and secondary dressings have been replaced by composite dressings composed by 4 to 5 layers with super absorbing materials incorporated in one of the layers which accumulates exudates from the wounds and also provides protection from leakage and thus avoiding cross infections which at times become a major concern. This article focuses on changing trends in the area of wound dressings through three decades.

INTRODUCTION: Human body has strong immune system with capabilities of self-healing. The protective layer of the skin protects the body against the external environment. The important layers of skin are Epidermis (outermost layer), Dermis (middle layer) and subcutaneous fat (deepest layer).

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The Epidermis consists of dead cells of keratin, which makes this layer water proof whereas dermis consist of living cells, blood vessels and nerves running through it, which provides structure and support.

The subcutaneous fat layer is responsible for insulation and shock absorbency [1]. In normal skin, there exists an equilibrium between epidermis and dermis [2].

Wound is defined as any cut or break in the layer of skin. The normal process of wound healing starts operating once the protective barrier is broken. Majority of wounds heal without any complication

because cells on the surface of the skin are constantly replaced by regeneration from below with the top layers sloughing off. However, in case of chronic non- healing wounds, there is more tissue loss and the natural process of healing is disturbed, thus special care is required for rapid and hygienic healing. This thus poses the biggest challenge for wound care product researchers and developers.

The purpose or aim of choosing a wound dressing is to protect the wound from infection, ease pain, promote healing and to avoid maceration. Usually, the selection of wound dressing depends on the type of the wound. Traditionally, different materials like neem paste, honey paste, turmeric, animal fats, etc. were used as wound dressing materials. But these traditional or homemade wound healing methods could not control the infection which hampers the healing process. Continuous efforts are in progress to develop wound dressings which can improve the healing process. Nowadays, different materials are in use for rapid and cosmetically acceptable healing. Thus materials are being developed with special emphasis on solving complexities of the healing process, speedy healing and prevention of scarring i.e., keloid formation or contractures.

Wound management and wound care has gained importance in recent years. Global market is flooded with different varieties of wound dressings. Some of the polymeric materials used in wound dressings are based on hydrogel materials, sodium alginate, hydrocolloid, collagen to mention a few. Different wound dressings are selected based on the type of wounds. The major problem of exudate management is a matter of concern. Advances have been made to achieve wound management with better absorption systems using superabsorbent polymers and developing layer dressing (composite dressings).

This paper reviews the various advances made in wound dressings with special focus on layered dressings with superabsorbent polymers.

Classification of Wounds: Wounds are different and unique. Each wound in itself has a different process of healing. Some wounds are internal some are external. The external wounds are easy to treat than internal because the visible wounds reflect their complications. The wounds are characterized on the basis of visibility, contamination, healing time, tissue loss, etc. [3]. The classifications are discussed in **Table 1**.

TABLE 1: VARIOUS CLASSIFICATIONS OF WOUNDS

S. No.	Classification – Basis	Types of Wound
Type-I	Healing	Acute: Possess no complication, heal rapidly & do not have any foreign matter Chronic: Possess some complications & healing takes longer time
Type-II	Exposure to the environment	Open: Tissues are exposed to the environment Closed: Tissues & organs are not exposed
Type-III	Visibility	Internal: Results from weak immune system or due to loss of nutrients or oxygen supply in that area External: formed by penetrating or non-penetrating trauma
Type-IV	Hygiene	Clean: have no foreign matter inside them Infected or contaminated: by dirt, bacteria & foreign material
Type-V	Texture	Non-penetrating wounds: Do not break through the skin viz., abrasions, lacerations, contusions, concussions Penetrating: Break through the skin &damages the tissue/organs below the skin like skin cuts, surgical wounds, gunshots, etc. Miscellaneous: like thermal wound, bites, stings, electrical wounds
Type-VI	Tissue loss	Superficial: epidermis is affected Partial Thickness: epidermis and dermis are affected Full thickness: epidermis, dermis & subcutaneous fat layer is involved
Type-VII	Appearance	Necrotic: covered with devitalized epidermis, frequently black in color. Sloughy: which contain a layer of viscous adherent slough, generally yellow in color. Granulating: which contain significant amounts of highly vascularized granulation tissue, generally red or deep pink in color Epithelializing : which show evidence of a pink margin to the wound or isolated pink islands on the surface

Stages of Wound Healing [4-7]: The wound healing process passes through four continuous phases namely haemostasis, inflammation, proliferation and remodelling or maturation.

a) **Haemostasis:** It is the primary or the initial stage wherein haemostasis begins, where injured part is healed by forming a clot which stops the blood loss.

b) **Inflammation**: It is the second stage. The phagocytes act to clear debris and destroy the ingested material. Inflammation is a result of breakage of fibrin clot and cleaning up the degradation products. The immune system of the body starts working to inhibit any pathogenic or microbial attack which leads to infection if not taken care. This stage usually takes 4 to 5 days.

c) **Proliferation**: It is the third stage. It usually starts from day 4 (after inflammation) and lasts until day 21. The proliferation involves overlapping of three actions: angiogenesis, granulation tissue formation and wound contraction. In angiogenesis, new blood vessels are formed which carry oxygenated blood to the wound bed.

   During granulation, the fibroblast cell grow forming a network of collagen fibres surrounding the wound resulting in reconstruction of the connective tissue, and contraction of the wound takes place pulling the wound inwards.

d) **Remodelling/ Maturation:** It is the fourth stage and may take years. Once the basic healing is done, a scar is left and it is at this stage, the wound repairing takes place and a scar formed is repaired. It is at this stage that collagen fibres are remodelled and realigned and cells that are no longer needed are removed by apoptosis.

Although the stages are defined but the healing is a complex process, the speed and manner of wound healing is affected by many factors that varies from person to person. The various factors are age, nutritional status, metabolic diseases, smoking, foreign bodies, inflammation and size, depth, causation and etiology of the wounds [8, 9].

Wound Management and Wound care: Wound healing is the body's natural process of regenerating dermal and epidermal tissues. Until 1900's, it was believed that wounds heal more quickly if they are dry and uncovered, thus the study of wound healing was somewhat neglected in 1900's. The significant advancement in wound care and wound healing came in 60's with Winter's work on wound dressings [10, 11].

His work showed that when wounds on pigs are kept moist the epithelial repair in the skin of pigs was at least twice as fast as seen in comparable dry air- exposed wounds. Thus it was concluded that maintaining a moist environment helped in wound healing. Later in 1963, Winters work was confirmed on human beings by Hinnman and Maibach [12]. Also an open wound which is dry and exposed to air will dehydrate but leaves a scar whereas healing done in moist environment does not leave scar as the dressing absorbs wound exudate secreted from the wound.

It was then sought that for an ideal wound management wound dressings play an important role. An ideal wound dressing is the one which helps in protecting the wound, maintaining a moist environment around the wound, should be permeable to gases, absorbs and retain the excess exudate and does not allow exudate to come out from its outer surface even under high pressure, removed easily and comfortably without any pain, does not cause any kind of allergy, controls the pH and temperature, protects the wound from micro-organisms and other foreign particles, minimize the pain, economical, cosmetically acceptable, prevents the wound desiccation, stops the growth factors, biocompatible and elastic [13, 14].

Changing decade gave different techniques of healing wound. The focus of wound management remained the same but eventually with time the methods improved. There was a time in early 1980's when water absorbing materials were cellulosic or fibre based products like tissue paper, sponge, cotton, etc. The water absorption capacity was 20 times their weight.

This then acted as a primary covering which was then covered with a secondary dressing, the bandages which were woven. These dressing found application for dry wounds and shallow wounds. After 1980's, traditional methods got replaced by the advanced dressings used for healing of chronic and acute wounds based on moist wound healing principle. **Table 2** below gives the changes observed with time in the area of wound management, especially for wound care involving wound dressings.

After it was observed that moist wound showed better healing from 1980-2000 the major research was focussed on developing dressings which can help in keeping the wounds moist, chronic wounds, deep wounds, high exudating wounds and other complications associated with wound healing. A step further in this area initiated to take care of tissue growth, formation of epithelial cells involving tissue engineering which could take care of chronic wounds, deep wounds, scar and other problems associated with wound care. It was after 2000, the Active or Bioactive Dressings came in action, and these were applied on to those wounds which could not heal up by the other dressings.

The bioactive dressings have an attractive antibiotic feature and make healing rapid. They not only shorten the healing time span but also make the wound less prone to infections. So these hydrogels, SAP and bioactive dressings have taken up the wound care management a step ahead of the previous invention on dressings and have undoubtedly replaced the traditional absorbent materials. This is the reason why we call these dressings as Third generation material. The materials not only have the capability of healing wounds but also creates barrier for pathogenic infections and is a composite dressing with a combination of primary, secondary and active dressings.

TABLE 2: EVOLUTIONS IN WOUND DRESSING

Several dressings have been developed. Classification of dressings was traditionally made on the nature of material rather than mode of action. These were then classified as conventional, biological and synthetic dressings. Each class were further classified as:

i) Primary dressings: The layer which was in direct contact with the wound was the primary dressings:

ii) Secondary dressings: The layer covering the primary dressings to further protect the wound was the secondary layer.

iii) Island dressings: It constituted of an absorbent core and a transparent layer with an adhesive on it.

These dressings have been developed using these concepts and have been categorised on the basis of their action as: Passive products, Interactive products and Bioactive products.

a) **Passive products**: Until 1970's, the dry wound dressings were considered to be the best for healing of the wounds. Passive product comes under dry wound dressings, i.e. the traditional dressings. These traditional dressings absorb exudate, act as a cushion for a wound, provide a dry environment, cover the wound from view and act as barrier to foreign bodies or any other contamination. These cover the largest market segment. Examples: gauze and tulle dressings.

i) **Gauze Dressing**: It is one of the commercial traditional dressings. It consists of woven cotton gauze or non-woven blends of rayon with other fibres (e.g. polyester or cotton). These are preferably used on minor wounds or as secondary dressings. Gauze dressings are mainly used for providing first aid to any injury but are not so common because of some disadvantages like disturbs the wound at the time of removal as these stick to the surface of the wound, provide dry environment to wound, used only for minor wound but not for chronic wounds, inability to provide proper permeability of gases and low absorption of wound exudates leading to accumulation of exudates at wound surface resulting in microbes attack and thus is unable to prevent microbial invasion.

ii) **Tulle Dressing**: These are also passive products but differ on the fact that they are made from petroleum jelly. These dressings find application for shallow wounds and avoid disturbing the wound when removed.

b) **Interactive Dressings**: They are capable of modifying the physiology of the wound environment and interact with the wound surface to optimise healing by promoting debridement and may also enhance granulation and reepithelialisation[15]. They provide a moist environment for improved healing. Interactive products comprise of polymeric films and foams, which are mostly transparent, permeable to water vapour and oxygen and impermeable to bacteria [16]. Some of the product which comes under the category of interactive dressings are: semi- permeable films, semi- permeable foams and hydrogels [17].

i) **Semi- Permeable Film Dressings**: Film dressings are thin dressings of polyurethane coated with acrylic adhesive which are permeable to gases but impermeable to liquid and bacteria. These are elastic and transparent allowing wound checks. These films are non- absorbent, thus they are not suitable for high exudating wound but suitable for shallow wound with low exudates. These may cause trauma to surrounding skin if removed incorrectly. They can also be used as secondary dressings to waterproof a primary dressing such as foam. Examples: Opsite, Tegaderm, Aqua protect film, Bioclusive, Cutifilm, Hydrofilm, Polyskin.

ii) **Semi- Permeable Foam Dressings**: These are made from polyurethane. Foams are available in the form of sheets or cavity filling shapes. They are highly absorbent i.e., absorb moderate to excess exudates and this decreases the risk of maceration. Foams provide moist environment to the wound. Depending on the level of exudates, foams can be left in place for seven days. Foams are generally non-adhesive and require secondary dressing or tape / bandage to keep in place [18].

These foam dressings are used for the protection of high trauma, infected wounds and also for autolytic debridement of yellow slough but not as useful as alginates or hydrocolloids for debridement. Examples: Allevyn, Cavi-care, Curafoam, Hydrosorb, Lyofoam, Permafoam, Tegafoam, Truefoam.

iii) **Hydrogel Dressings**: Hydrogels are hydrophilic gels. They are covalently linked 3D network of hydrophilic polymer. They can absorb and withhold large quantities of water without dissolving as these polymers have hydrophilic functional groups attached to their backbone. At the same time, they have cross- links between network chains, due to which these polymers do not dissolve in water and serve as matrix to hold water together. Hydrogels are designed to hydrate wounds, providing an ideal environment for

wound healing. With their high moisture content, they help to prevent bacteria and oxygen from reaching the wound, providing a barrier for infections. These dressings are very soothing and cooling due to their moisture content which is essential in pain management especially in case of burns and painful wounds. They may contain up to 95% water, which is perfect for keeping skin and tissue hydrated.

Thus, hydrogel dressing is good for dry and necrotic wounds as it rehydrates the wound bed and provides a moist environment for healing [19- 24]. Usually, hydrogel dressings are used to treat wounds like diabetic ulcers, pressure sores, surgical wounds, burns and skin tears. These hydrogel dressings are non adhesive to the wound, thus can be easily removed without causing any pain. They are biocompatible i.e., they don't harm the body [25]. They are available in the form of sheet (i.e., fixed hydrogel- sheet) or are applied onto or into wound and covered with other secondary dressings (i.e., amorphous hydrogel- gel).

- Amorphous Hydrogel: This is a free-flowing hydrogel which possess easy application to the cavity space in the wound. They are usually available in tubes or as spraying agent which are impregnated onto the passive dressings. They are used as fillers for deep wounds. They need secondary dressings to keep them in place [26, 27].

- Fixed Hydrogel: In this, the hydrogel is fixed within the sheet forming thin flexible sheets. Sheet based hydrogel are suitable for minimal exudates absorption. They support wounds like abrasions, skin tears, blisters, donor sites, surgery sites etc. They provide padding but cannot withstand the external pressure.

Hydrogels have all the characteristics that are required in an ideal wound dressing but the main disadvantage of hydrogels is their poor mechanical properties after swelling. On swelling, they may degrade, eventually disintegrate and dissolve [13, 18]. They are non-adherent and can be removed without trauma to wound bed. Examples: Tegagel, Intrasite gel, Solugel, Solosite gel, Curafil (amorphous gel), Purilon (amorphous gel), Aquaclear, Duoderm, Hypergel, Nu-gel, Sterigel.

c) **Bioactive Dressings:** These dressings deliver substances in wound healing. These are usually used for treating acute burn injuries and chronic wounds (pressure ulcers, venous ulcers and diabetic foot ulcers) which are not healed easily by the other type of dressings. The prominent property of bioactive dressing is their ability to combat microbial infection and anti-biotic feature which promotes healing and controls infection. These include the well- known iodine and silver dressings like Iodosorb, Actisorb Silver 220, and Acticoat [28]. Actisorb silver 220 is an activated charcoal cloth impregnated with silver, which absorb bacteria which are then inactivated by the silver. It is used over partial and full thickness wounds [29]. Some products which come under the category of bioactive dressings are: alginates, chitosan, hydrocolloids, hydroactive, hydrofibres, collagens, iodine dressing, and silver dressing, zinc paste bandages, etc.

i) **Alginate Dressings**: Alginates are naturally occurring polysaccharides composed of the sugars: β-D-mannuronic acid and α-L-guluronic acid with exclusively 1, 4 glycosidic linkages [30]. Alginates are high absorbent biodegradable dressings derived from seaweed and are composed of calcium alginate or a combination of calcium and sodium alginate [31]. These calcium-alginate fibres of the dressings when come in contact with the wound, calcium in the dressing are exchanged with sodium from wound fluid and turns dressings into a gel i.e., water soluble sodium- alginate that maintains a moist environment which ultimately leads to better healing of the wound [16]. Calcium dressings need moisture/exudates from the wound to function. Therefore they are good for exudating wounds and helps in debridement of sloughing wounds. They are not suitable

for dry or low exudating wounds because the fibrous nature of alginates can leave residual fibres in the wound if there is insufficient wound exudate to gel the fibres which causes dryness and scabbing. Alginates can absorb 15- 20 times their own weight. This absorptive capacity of alginates makes them suitable for the treatment of heavily draining wounds. Alginate dressings are available in sheet, ribbon or rope form and require a secondary dressing. The gel forming property of alginate helps in removing the dressing without much trauma and reduces the pain experienced by the patient during dressing change [32- 36].

ii) **Chitosan Dressings**: Chitosan is a valuable natural polymer derived from chitin. Chitosan is known in the wound management field for its anti-viral, anti-fungal, non-toxic, non-allergic, biocompatible, biodegradable properties and helps in faster wound healing but it exhibits excellent anti-bacterial activity [37, 38]. Chitosan dressings show scar prevention which is the most important criteria in today's world of wound dressing technology [39]. Chitosan wound dressing has excellent oxygen permeability, controlled water loss and water-uptake capability. There are number of references on chitosan in wound treatment [40-45].

iii) **Hydrocolloid Dressings**: Hydrocolloids form a set of dressings which heals the wound by providing occlusion. These contain gel-forming agents such as carboxymethylcellulose, gelatin, pectin, elastomers and adhesives that turn into hydrated gel over wound surface when exudates is absorbed. This gel gets separated during dressing removal, avoiding damage to newly formed skin. This creates a warm, moist environment that promotes debridement and healing. They are capable of absorbing a moderate amount of wound exudates. However, oversaturation of dressing may lead to leakage of the gelatinous substance causing maceration of the surrounding skin. They are available in the form of adhesive or non-adhesive pad/sheets, paste, and powder but most commonly as self-adhesive pads [46, 47]. Example: Duoderm, Tegasorb, Comfeel, Combiderm, Hydrocoll, Replicare.

iv) **Hydroactive Dressings**: They are highly absorbent, non-residual, semi permeable and waterproof polymer dressings. They have a similar multilayered structure as hydrocolloids but instead of forming a gel in contact with the exudates, the fluid from the wound is trapped within the dressing which maintains a moist environment. They are highly absorbent and used in highly exudating wounds but not used for dry or lightly exudating wounds. They are useful over joints as they expand or contract without causing any problem. Examples: Allevyn Thin, Biatain, Cuinovahydro, Polymem, Tielle.

v) **Hydrofibre Dressings**: Hydro fibre dressings are soft nonwoven pad/ sheet or ribbon packing dressings made from sodium carboxymethylcellulose fibres. These dressings absorb exudates and on absorption the fibres of these dressings convert to form a soft gel which provides a moist wound healing environment. It is used for deep wounds that need packing. These dressings have more absorbing capacity than alginates and can be removed without causing any trauma. Example: Aquacel.

vi) **Collagens**: These dressings are available in the form of pads/sheets and gel. They absorb the exudates and provide a moist environment. They promote the wound healing by deposition of newly formed collagen in the wound bed [16].

vii) **Iodine Dressings**: It is a three- dimensional polysaccharide lattice which contains 0.9% iodine. These dressings absorb exudates and on absorption the polysaccharide of these dressings swell and form a gel which provides moist wound healing environment and from this gel iodine is gradually released into the wound. They absorb the

fluid six to seven times its weight and thus they are useful for heavily exudating wound [18]. Example: Iodiosorb

The choice of wound dressing depends on the type of wound and also on wound depth as discussed in **Table 3** below.

TABLE 3: DRESSING CHOICE BY WOUND APPEARANCE

Wound Type (Colour/ exudates)	Goal	Wound Depth	
		Superficial	Cavity
Black/ Low exudates	• Rehydrate/debride	• Hydrogels • Hydrocolloid • Gauze • Enzyme	• Hydrogel • Hydrocolloid • Gauze • Enzyme
Yellow/ High exudates	• Remove slough • Control exudates	• Hydrocolloid • Exudate Absorbers • Enzymes • Gauze	• Hydrocolloids (paste, granules, powder) • Exudates absorbers • Enzymes • Foam cavity dressings
Yellow/ Low exudates	• Remove slough • Control exudates	• Hydrogel • Hydrocolloid • Enzymes • Film • Gauze	• Hydrocolloids (paste, granules, powder) • Hydrogel • Gauze • Enzyme • Foam cavity dressings
Red/High exudates	• Absorb exudates • Maintain moist environment • Promote granulation & epithelialisation	• Foams • Hydrocolloid • Exudate absorbers	• Hydrocolloids (paste, granules, powder) • Exudate absorbers • Foam cavity dressings
Red/ Low exudates	• Moist environment • Promote granulation & epithelialisation	• Hydrogel • Hydrocolloid(thin) • Enzymes • Film • Non-adherent	• Hydrocolloids (paste, granules, powder) • Hydrogel • Foam cavity dressing

Another criterion of choosing a wound dressing depends on the quantity of exudates from the wound. **Table 4** below shows that the choice of dressings can be foams, films, speciality absorbents.

TABLE 4: RELATION BETWEEN TYPES OF DRESSINGS AND EXUDATING WOUNDS

Types of dressings	Exudate amount			
	None	Small	Moderate	Large
Films				
Hydrogels				
Hydrocolloids				
Alginates				
Foams				
Speciality absorbents				

Speciality absorbents are class of dressings which deal with superabsorbent polymers (SAP). These are class of hydrogels which can absorb and retain large amount of liquid relative to their own mass. Apart from wound dressings they are also being used in the different fields like agriculture, wound care management, environment industry, diaper industry, etc. SAPs are a class of cross linked polymer capable of absorbing and retaining water. This crosslinking enhances the absorption capacity of SAP to 500 times. This crosslinking does not allow SAP to dissolve but forms a gel when placed in water. The total absorbency and swelling capacity are controlled by the type and degree of crosslinkers used to make gel. The highly crosslinked polymer exhibits low absorption capacity but the low crosslinked polymer dissolves in the liquid. Therefore, optimum cross linkers are used to develop superabsorbent polymers so that they exhibit high absorption capacity.

SAPs are synthesized from different type of polymerisation techniques like copolymerisation, gel polymerisation, solution polymerisation, suspension polymerisation, etc. Each technique gives different type of polymer varying in its texture, density, volume, mass, etc.

SAP's are usually classified on the basis of raw material sources which is synthetic (petrochemical based) and natural sources. The synthetic based SAPs are acrylic acid, etc. The natural sources are polysaccharides, polypeptide, amino acids, etc. Synthetic materials like acrylic compounds are usually added in the natural material for forming SAP. This addition is because of high absorption capacity of acrylic compound which improves the absorption capacity of the SAP derived from natural sources [48-50].

Technology involved in SAP based dressings [51]: Superabsorbent dressings possess superabsorbent polymer which has 3-D hydrophilic networks that can absorb and retain huge amount of water or aqueous solution. The superabsorbent polymers are now being used in wound dressings to absorb large amount of exudates from the injury site. These dressings are so designed to manage and absorb exudates. The Superabsorbent dressings are made up of number of layers.

There are mainly 3 to 4 layers depending on the company which manufactures. Each layer has its own function in absorbing and retaining the fluid and creating the correct environment for rapid healing [**fig. 1**].

Layer A: The first layer of superabsorbent dressing is the layer which is in direct contact with the wound. This layer is made from the non- fabric which helps in preventing adhesion to the wound.

Layer B: The second layer is distribution layer. This layer is usually called wicking layer. This wicking layer ensures the proper distribution of the fluid across the dressing. Both horizontal and vertical wicking takes place. The wicking layer is a fabric which is usually used for the uniform distribution of fluid.

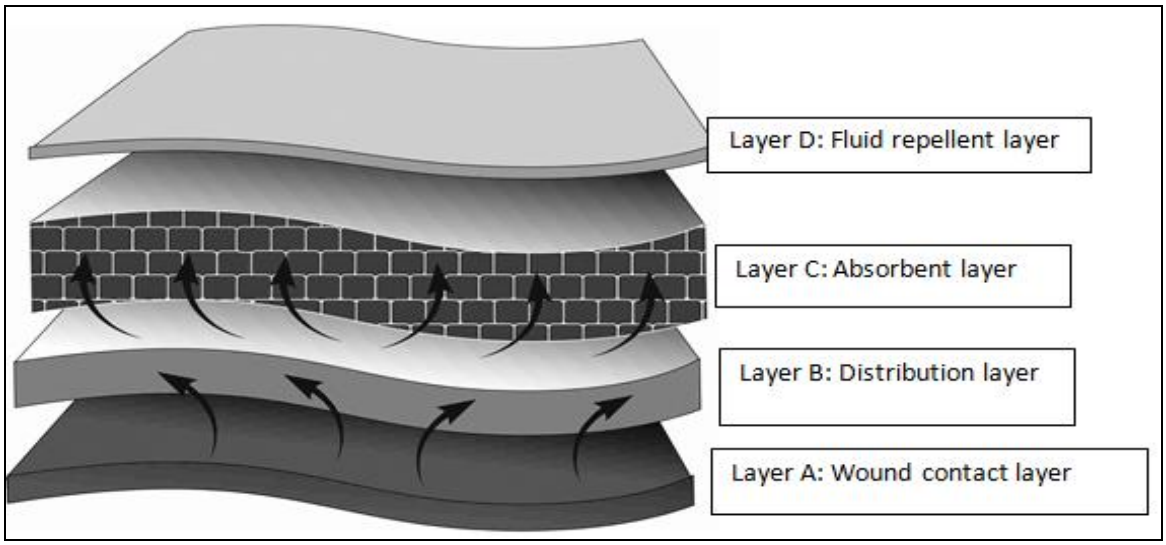

FIG 1: LAYER STRUCTURE OF SAP

Layer C: The Third layer of superabsorbent dressing is the layer which contains superabsorbent polymer and is called absorbent layer. The crystals are spreaded evenly on the second layer. As soon as the exudate comes in contact with the superabsorbent polymer, the polymeric layer expands after absorbing and retaining the moisture. After absorbing the exudates, the polymer forms gel and locks the fluid [**fig. 2**]. The formation of gel confirms the permanent retaining of exudates. Due to this fact, a single dressing can be used for several days.

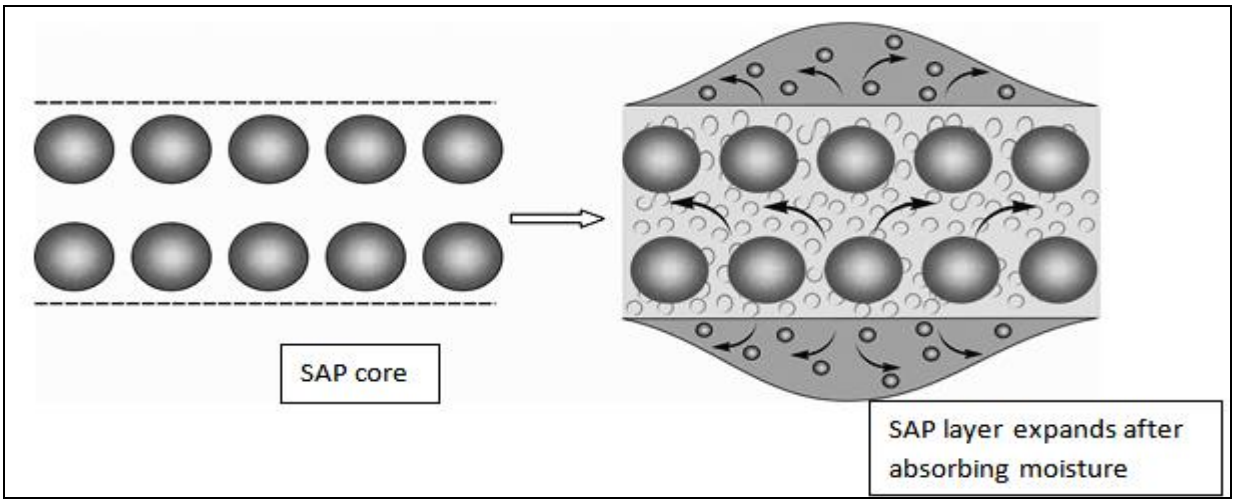

FIG. 2: SAP SWELLING

Layer D: The fourth layer is the outer covering of the dressing which is in contact with the clothing, bed sheets etc. This layer should be hydrophobic, if not, then it can spoil the clothing, other dressings etc and thus it is referred as fluid repellent backing layer. The dressing possesses a strike through area which means that even under external pressure, the exudates doesnot move out to other side. Non – woven fabric is used for packing layer and these layers are made in such a manner that it can act as a barrier for the bacteria but should be permeable to oxygen and water vapour.

These layers as discussed above are jointly used as wound dressing which are packed with the help of adhesives. These adhesive packing is such that it provides protection and comfort. One dressing is capable of acting as both primary and secondary dressing. Market available products based on SAP technology are Mextra, Zetuvit Plus, Xtrasorb [52].

The number of layer can be increase from 4 to 5 layers [53] shown in **Fig. 3**.

Layer A (Thin Film Layer): This layer usually composed polyurethane, polyethylene, etc. It may be perforated throughout in order to improve the moisture and vapour permeability of the wound dressing. Thin film layer may also be transparent.

Layer B (Backing layer): It may be constructed of a porous foam material or non- porous transparent polyurethane. The backing layer is adhered to the thin film layer by means of adhesive layer. It is transparent to permit viewing of the healing process without removal of wound dressing. It prevents the thin transparent layer from curling and helps in handling of the dressing during its application. It is permeable to both vapour and moisture.

Layer C (Support layer): This layer is present only when the backing layer is composed of porous material. The support layer is made from a permeable fabric such as woven and non- woven fabrics, gauze or some other materials.

Layer D (Hydrogel/SAP layer): Along the support layer, there is hydrogel/SAP layer. The support layer adds increased stability and support to the hydrogel/SAP material. The dressing in which support layer is not used, the hydrogel/SAP material is secured directly to the second side of the porous backing layer. The gel-like hydrogel/SAP material is positioned within the centre portion of thin film layer.

Layer E (Release Liner): After the hydrogel/SAPs material overlies a silicon- coated release liner. The

perimeter portion of the release liner is attached to the thin film layer by means of an adhesive from this and an optional removable tab is interposed between the thin film layer and release liner. This removable tab facilitates the handling of wound dressing.

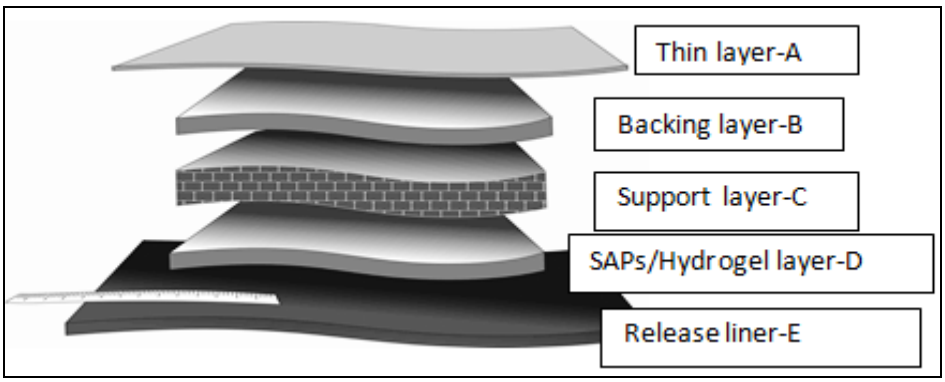

FIG. 3: COMPOSITE DRESSING WITH FIVE LAYERS

CONCLUSION: Wound dressing and wound management is an active area of research developing biocompatible dressings with more focus on bioactive materials incorporating growth factors. Speciality absorbents are the need for treatment of chronic wounds, highly exudating wounds, and in total cosmetically acceptable healing.

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