“SPRAY-ON BANDAGE”; AN OVERVIEW


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ABSTRACT

A Spray-on bandage is a special liquid version that is sprayed on via a pump much like a hairspray container. In other words, a bandage formed in situ on a wound by spraying on separately or simultaneously a hydrophilic water-insoluble polymer and a high boiling plasticizer or solvent therefore. They are most often used to cover and protect small cuts, minor scraps but not major wounds. This review summarizes insights into the preparation procedure and evaluation methods of spray-on bandages, their different existing forms with different drugs and polymers and plasticizers (marketed and research) and their future development as a novel drug delivery system.

KEYWORD: different drugs, polymers and plasticizers.

INTRODUCTION

The skin is the largest organ in the body and is very adaptable to the environment. The main functions of the skin are to protect against microbial invasion, to aid in thermal regulation, and to prevent water loss. The research and development of medicated films for cosmetic and dermatological uses have been topics of great interest in recent years. Many of these preparations are done in pressurized packages and are known as "spray-on bandages." They are generally two-phase aerosols containing plain or medicated resin dressings, an organic solvent, and a propellant. Although these products have been widely accepted because of their convenience they have some shortcomings. They usually deposit a film on the skin which cannot be washed off. The organic solvent systems prevent the incorporation of drugs which are soluble only in water. Although, researches are still going on to overcome these shortcomings.
Preparation of spray on bandages mark the starting point as the formulation of the aerosol concentrate. The major ingredient in the concentrate is the resinous film-forming agent. Several resins were investigated with different plasticizers.

THE MAIN REQUIREMENTS OF THE POLYMERS USED IN SPRAY-ON BANDAGES

- Non-tackiness.
- Sufficient hydrophilic character to possess vapor permeability of at least 200 grams/sq. meter/24hours/mil, preferably at least 500 grams/sq.meter/24hours/mil.
- Susceptibility to salvation (plastisol formation) by the useful polar plasticizer-solvents.
- Insolubility in water.
- Sufficient friability to be able to be prepared as a finely divided powder, e.g. less than 100 mesh and preferably less than 200 mesh (Tyler screen series).

NATURAL AND SYNTHETIC RESINS/POLYMERS FOR SPRAY-ON BANDAGES:

NATURAL POLYMERS
1. Chitosan,
2. Alginate,
3. Starch,
4. Collagen,
5. Gelatin,
6. Cellulose,
7. Dextran,
8. (1→3)-β-D-glucans,
9. Alginic acid and hyaluronic acid,
10. Heparin,
11. Chondroitin,
12. Dermatan and keratan sulphates,
13. C-P02 polymer (water based polymer obtained from bacterium, is non-cytotoxic and biodegradable)
14. Fibrin,
15. Nitrocellulose, etc.
SYNTHETIC POLYMERS
1. Acrylate terpolymer
2. Polyphenyl methyl siloxane
3. Polyvinyl alcohol
4. Pyroxylin
5. Polyacrylate
6. Dipropylene glycol
7. Propanediol
8. Polylactic acid
9. Poly-ε-caprolactone
10. Polyvinyl pyrrolidine (PVP)
11. Polyethylene alcohol
12. Octanyl cyanocrylate
13. Poly lactic co-glycolic acid (PLGA),
14. Hydroxy ethyl acrylate,
15. Hydroxyl ethyl methacrylate,
16. Hydroxy propyl acrylate, etc

- Plasticizer-solvents useful for film formation in combination with the polymer-powders include water soluble polar compounds including glycols such as propylene glycol, ethylene glycol, trimethylene glycol, butanediol-1,3, butanediol-1,4, hexanediol-2,5, 2-methyl-2,4-pentanediol, heptanediol-2,4, 2-ethyl-1,3-hexanediol, diethylene glycol, triethylene glycol, tetraethylene glycols and other polyethylene glycols having a molecular weight upto 800.

The ratio of the plasticizer-solvent to the polymer is not particularly very important but studies has shown that satisfactory results were obtained in the range from 80%-20% polymer to 20%-80% plasticizer-solvent, more preferably 30%-70% polymer to 70%-30% plasticizer-solvent. The film can be built up to any desired thickness on the skin but is usually about 10 mils.

REQUIREMENTS FOR FULLY ACCEPTABLE SPRAY-ON BANDAGES
- It protects the wound from air – borne bacteria and dirt.
- It has moisture vapor permeability sufficient to prevent accumulation of aqueous fluid under the bandage.
It must be non-toxic and non-irritant.
It should not adhere to the wound area or permit infiltration by regenerating tissue.
It should not cause a burning or stinging sensation when applied.
It should not be water soluble or render tacky by contact with water to avoid dirt accumulation.
It should be readily removable when desired.

PREPARATION OF SPRAY-ON BANDAGES
- Water-insoluble, hydrophilic powder polymers, having high moisture permeability were incorporated to high boiling non-toxic polar plasticizer-solvents, to form films.
- Medically active ingredients can be incorporated in the film; which will diffuse from the film to the wound area over extended periods of time.
- Active ingredient can be incorporated in the film by either:
  1. Having them impregnated in the polymer, or
  2. Mixing the active ingredient with the polymer powder, or,
  3. Dissolving or dispersing the active ingredient in the high boiling plasticizer-solvent.
- It is most conveniently applied using aerosol spray techniques although a layer of liquid followed by a layer of polymer can be applied by brushing, dabbing, etc.
- In some cases, the powder and liquid are applied from the same can in which case, the presence of the propellant in the can prevents solvation and agglomeration of the powder by the plasticizer-solvent.
- Suitable propellants include – these can be compressed gases such as carbon dioxide, nitrous oxide, nitrogen, liquefied volatile hydrocarbons such as propane, n-butane, isobutene and 2-methyl butane, methylene chloride, vinyl chloride, fluorinated compounds including perhalogenated compounds and fluorinated hydrocarbons such as dichlorofluoromethane, trichlorofluomethane, vinyl fluoride, etc.
- The propellant should contain a substantial amount of volatile material boiling at not over 20°C, but there can be presence of less volatile material boiling up to 50°C.

Evaluation of the formed films when sprayed on the skin can be carried out by evaluating:
- The film strength,
- Tackiness,
- Adherence time,
- Flexibility and
- Water resistance capacity.
## MARKETED SPRAY ON BANDAGES AND THEIR COMPOSITIONS

<table>
<thead>
<tr>
<th>S.N</th>
<th>PRODUCT NAME</th>
<th>CHEMICALS USED</th>
<th>POLYMERS USED</th>
<th>CATEGORY</th>
<th>APPLICATIONS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>3M – Nexcare liquid bandage spray</td>
<td>Hexamethyl disiloxane, isooctane</td>
<td>Acrylate terpolymer, polyphenylmethy siloxane</td>
<td>Anti -microbial</td>
<td>Waterproof, soothing, breathable, alcohol free,</td>
<td>Not for larger areas</td>
</tr>
<tr>
<td>3.</td>
<td>Medtech labs New- skin liquid bandage spray 1oz</td>
<td>8 – hydroxyquinoline 1%, alcohol 4.2 %, isobutene propane, oil of clove</td>
<td>Pyroxylin solution</td>
<td>Anti septic, anti bacterial,</td>
<td>Waterproof, flexible, breathing.</td>
<td>Not for large areas, Do not store above 120F</td>
</tr>
<tr>
<td>4.</td>
<td>Medique Medi – First pain relief blood coating spray</td>
<td>Benzethonium chloride 0.2% w/w, Lidocaine 4% w/w,</td>
<td>Anti – septic, disinfectant</td>
<td>Blood clotting, fights infection, stops superficial bleeding</td>
<td>Flammable, Fast acting spray, not for larger areas</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>New skin liquid bandage – spray</td>
<td>8 - Hydroxyquinoline 1%, amyl acetate, benzalkonium chloride, castor oil, clove bud oil, ethyl alcohol, isobuten-propane, n- butyl acetate</td>
<td>nitrocellulose</td>
<td>Anti – bacterial, anti –septic</td>
<td>Waterproof, breathable, for larger affected areas.</td>
<td>Do not apply over larger areas, Flammable above 120 F</td>
</tr>
<tr>
<td>6.</td>
<td>Kericure natural seal spray bandage</td>
<td>water</td>
<td>Pure Polyacrylate</td>
<td>Antiseptic</td>
<td>Waterproof, prevents infection, seals bleeding</td>
<td>Suitable for all ages and With sensitive skin, water based spay</td>
</tr>
<tr>
<td>7.</td>
<td>Medical adhesive spray bandage</td>
<td>Sod. Tetraborate, ascorbic acid</td>
<td>propanediol</td>
<td>Anti infective</td>
<td>Wound dressing, repairing and healing</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Nexcare no sting liquid bandage spray</td>
<td>Hexamethydisiloxane</td>
<td>Acrylate terpolymer, Polyphenylmethy siloxane</td>
<td>Anti infective</td>
<td>For minor scrapes and abrasions, waterproof</td>
<td>Not for large, deep ,puncture wounds, serious bands or animal bites, Not for use in chronic skin conditions.</td>
</tr>
<tr>
<td></td>
<td>Product Description</td>
<td>Active Ingredients</td>
<td>Properties/Actions</td>
<td>Notes</td>
<td></td>
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<tr>
<td>9</td>
<td>Banda- sil liquid bandage spray, silver 1 oz</td>
<td>Silver (silver oxide)</td>
<td>Anti infective, protectant</td>
<td>For minor cuts, abrasions, lacerations, flexible, long lasting, non toxic, alcohol and triclosan free; Not for major cuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Curad – spray bandage 1oz</td>
<td>Dimethyl ether, ethanol</td>
<td>Anti infective</td>
<td>Minor cuts, waterproof, healing, Hazardous combustion products; CO2, CO, NO. aerosol inhalation causes irritation to nose and urot, not completely biodegradable.</td>
<td></td>
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</tr>
<tr>
<td>11</td>
<td>JUC spray dressing 30ml</td>
<td>Water soluble macromolecular cationic active agent, i.e, 2% of organosilicon quarternary ammonium salt &amp; 98% of distilled water</td>
<td>Anti microbial</td>
<td>Wound (cut / burn), rapid healing, physical, antimicrobial. Solves acute leg abrasion &amp; has no drug resistance, Substitutes local antibiotics in treatment of leg abrasion as it avoids drug resistance.</td>
<td></td>
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</tr>
<tr>
<td>12</td>
<td>Functional wound care dressings (5ml, 10ml, 30ml)</td>
<td>Ascorbic acid, sodium tetraborate, water</td>
<td>Anti bacterial</td>
<td>Easy to apply, healing, sterilizing. It eliminates edema and is anti allergic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Swift Aerosol spray bandage, 3 oz</td>
<td>Benzocaine 1.92%, Benzethonium chloride 0.012%</td>
<td>Anti infective</td>
<td>Provides coating for minor injuries, minor insect bites. Water soluble, flammable contents under pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Medi – Firstantineptic spray, 3 oz</td>
<td>0.05%, cetyl trimethyl ammonium Bromide, 4.5%, Benzocaine</td>
<td>Anti septic and anti infective</td>
<td>Wound care, for cuts and abrasions, minor cuts Provides a fast &amp; easy way to disinfectant, helps minimize pain.</td>
<td></td>
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</tr>
<tr>
<td>15</td>
<td>First Aid Only, Aerosol Spray Bnadage, 3 Oz</td>
<td>Benzocaine 3.2%, Benzethonium chloride 0.2%</td>
<td>Anti infective</td>
<td>Protects cuts and abrasions, prevents infection, assists healing. Water soluble, washable, contains no fluorocarbons, environmentally safe, extremely flammable under pressure.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## RESEARCH STATUS FOR SPRAY-ON BANDAGES:

<table>
<thead>
<tr>
<th>S. NO</th>
<th>WEBSITE</th>
<th>DATED</th>
<th>TITLE</th>
<th>RESEARCHERS</th>
<th>CHEMICALS &amp; POLYMERS USED</th>
<th>PURPOSE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><a href="http://www.library.calstate.edu">www.library.calstate.edu</a> published in: Dermatology, vol.20,issue 4</td>
<td>30/11/1999</td>
<td>The effect of new tissue adhesive wound dressing on the healing of traumatic abrasions</td>
<td></td>
<td>Octylcyanoacrylate (medical grade adhesive with antimicrobial properties)</td>
<td>Healing of traumatic abrasions</td>
<td>Well tolerated &amp; did not showed any signs of histotoxicity or adverse wound healing.</td>
</tr>
<tr>
<td>4</td>
<td>OnlineLibrary.wiley.com (journal of pharmaceutical sciences)</td>
<td>17/9/2006</td>
<td>Invivo method for determining effectiveness of spray on bandages containing anti- infectives.</td>
<td></td>
<td>Neomycin sulfate and triclosan</td>
<td>Reduces degree of infection</td>
<td>Till now done with guinea pig.</td>
</tr>
<tr>
<td>6</td>
<td><a href="http://www.sci.techdaily.com">www.sci.techdaily.com</a></td>
<td>10/1/2012</td>
<td>Nanaoscale biological coating instantly stops bleeding</td>
<td>MIT researchers</td>
<td>Tannic acid &amp; thrombin</td>
<td>Halts bleeding within seconds and heals</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><a href="http://www.link.springer.com">www.link.springer.com</a> (pharmaceutical research)</td>
<td>8/11/2012</td>
<td>Evaluation of wound healing potential of β –</td>
<td>B- chitin powder, methanol, CaCl2,</td>
<td></td>
<td>To heal wounds faster</td>
<td>Showed blood coating ability &amp; platelet activation</td>
</tr>
<tr>
<td>No.</td>
<td>Website</td>
<td>Date</td>
<td>Description</td>
<td>Researchers</td>
<td>Composition</td>
<td>Application</td>
<td>Summary</td>
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<td>8.</td>
<td><a href="http://www.highbeam.com">www.highbeam.com</a> (states news service)</td>
<td>3/8/2013</td>
<td>‘Spray on skin’ - Treatment for leg ulcers</td>
<td>Researchers from the University of Miami &amp; other institutions in UK.</td>
<td>Combination of donated skin cells and proteins</td>
<td>Treats venous leg ulcers</td>
<td>Trial was promising, further trials done for testing safety &amp; effectiveness in larger group of people.</td>
</tr>
<tr>
<td>9.</td>
<td><a href="http://www.chitosil.com">www.chitosil.com</a></td>
<td>16/09/2013</td>
<td>Chitosil wound care liquid bandage (alcohol free)</td>
<td>Researchers from the University of Maryland</td>
<td>Chitosan and silver complex</td>
<td>Fast healing and clotting</td>
<td>Found most effective due to antimicrobial properties</td>
</tr>
<tr>
<td>10.</td>
<td><a href="http://www.damngeeky.com">www.damngeeky.com</a></td>
<td>1/04/2014</td>
<td>Spray on bandage capable of protecting and healing serious wounds</td>
<td>Researchers from the University of Maryland</td>
<td>(Poly lactic-co-glycolic-acid)PLGA &amp; acetone</td>
<td>Protects from any kind of infection</td>
<td>Going through safety studies, soon will enter animal surgical trials.</td>
</tr>
<tr>
<td>11.</td>
<td><a href="http://www.dogonews.com">www.dogonews.com</a></td>
<td>23/10/2014</td>
<td>Smart spray on bandage reports healing progress by lighting up</td>
<td>Researchers from USA, South Korea &amp; Germany. Later by Harvard Medical School Asst. Prof. Conor Evans.</td>
<td>Phosphorescent material reacts with oxygen</td>
<td>Healing progress by lighting up</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td><a href="http://www.springer.com">www.springer.com</a> (applied science)</td>
<td>21/8/2015</td>
<td>Characterization and study of antibacterial activity of spray pyrolyzed ZnO: Al thin films</td>
<td>Researchers from USA, South Korea &amp; Germany. Later by Harvard Medical School Asst. Prof. Conor Evans.</td>
<td>ZnO, Al</td>
<td>Antibacterial properties</td>
<td>The effective incorporation of Al into ZnO lattice yielded a well pronounced antibacterial activity against S.aureus</td>
</tr>
</tbody>
</table>

**CONCLUSION**

SPRAY-ON BANDAGES marks itself for future development as a novel drug delivery system, Since, it is known from the collected data that spray-on bandages are used for minor cuts, scraps, etc and are usually incorporated with antimicrobials, anti-infectives, anesthetics, antiseptics, disinfectants, etc. But, nowadays spray-on bandages are being prepared by incorporating drugs such as NSAIDs, etc. targeting inflammation and pain, not major but minor, since, they are far more convenient to apply and use as compared to other adhesive formulations. Also, formulations have been developed by incorporating both NSAIDs and antimicrobials, as the core reason for infection and wound rises from inflammation itself. Formulations using different natural polymers (gelatin) as a skin substitute for wounded skins were also developed.
REFERENCES
13. 9 - Dry wound healing concept using spray-on dressings for chronic wounds • Advanced Wound Repair Therapies, 2011.
24. Skin Tissue Engineering and Regenerative Medicine, 2016.