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Design and Preparation of Novel Anti-adhesion Extra Thin Polyvinyl Alcohol Foam Dressings for NPWT *via* a Combined Procedure of Ultra Precision Machining and Super Clean Air-foaming

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***Abstract*—Negative pressure wound therapy(NPWT) utilizes foam dressings to create an optimal healing environment. The anti-adhesion material was important for the clinic application of NPWT treatment. Polyvinyl alcohol (PVA) foam dressing could be considered as a good anti-adhesion material for NPWT treatment. An anti-adhesion extra thin foam dressing with good mechanical property would be a potential medical device for NPWT treatment. A series of anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings with different macroporosities and thickness of 1.5 mm were designed and prepared. Mechanical property of the resulting extra thin foam dressings was determined. Preclinical evaluation of new designed anti-adhesion extra thin PVA foam dressings could be established by determining water morphology, water permeability, macroporosity, mechanical property of resulting samples.**

***Keywords*—PVA; foam; matrix**

I. INTRODUCTION

The novel design of the medical device could be developed and applied for new microscopic surgical procedures instead of the traditional surgical procedures. For the design of new medical devices, selections of materials or suitable materials for biomedical applications such as polymethacrylate, polyester, polynorbornene, and polymeric resins could be substantially considered and employed [1–6]. Also, the surface modification technology could be considered to change the surface microenvironment of materials for specific need [7-8]. Furthermore, the biological and clinical evaluations of materials and medical devices by using polyvinyl alcohol(PVA) foam must be considered for the application and design[9-14]. Negative pressure wound therapy (NPWT) is a medical procedure in which a sealed wound dressing containing a foam matrix structure attached to a pump to create a negative pressure environment in the wound, which promotes wound healing in acute, chronic and burn wounds. In usual, applying continued vacuum helps to increase blood flow to the area and draw out excess fluid from the wound[9-14]. Two sponges are available for Negative pressure wound therapy (NPWT) [14]. In usual, a black polyurethane (PU) sponge with a pore size of 400–600 μm intended for deep defects as granulation is strongly promoted and the pore size is suitable for heavy secretions. With a longer duration of application, it can grow together with the wound's base. This can be prevented by placing gauze under the sponge also facilitating dressing change. For more superficial ulcerations there is a 90–120 μm, which promotes granulation to a lesser degree and is suitable for wounds with less secretion. This sponge can remain on the wound for up to five days[14]. New anti-adhesion extra thin polyvinyl alcohol foam dressings derived from a Combined Procedure of ultra-precision machining and super clean air-foaming were designed for negative pressure wound therapy (NPWT). Preclinical evaluation of new designed anti-adhesion extra thin polyvinyl alcohol foam dressings could be established by determining water morphology, water permeability, thickness, macroporosity, mechanical property of resulting samples.

II. EXPERIMENTAL

A. Materials

A novel anti-adhesion extra thin polyvinyl alcohol foam dressing for NPWT was designed [2] via a super clean air-foaming processs. The medical grade Cenefom PVA materials were employed in this work(PARSD Pham. Tech. Co.). Negative pressure wound therapy(NPWT) utilizes foam dressings to create an optimal healing environment. The anti-adhesion material was important for the clinic application of NPWT treatment. Polyvinyl alcohol (PVA) foam dressing could be considered as a good anti-adhesion material for NPWT treatment. An anti-adhesion extra thin foam dressing with good mechanical property would be a potential medical device for NPWT treatment. A series of anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings with different macroporosities and thickness of 1.5 mm were designed and prepared such as PVAETF1, PVAETF2, and PVAETF3(Figure I). Mechanical property of the resulting extra

thin foam dressings(PVAETF1, PVAETF2, and PVAETF3) was determined.

FIGURE I. PHOTOS OF THE RESULTING EXTRA THIN FOAM DRESSINGS FOR NPWT(A)PVAETF1, (B) PVAETF2, AND (C) PVAETF3

B. Mechanical Property

Mechanical property of the resulting extra thin foam dressings(PVAETF1, PVAETF2, and PVAETF3) was determined.

C. Macroporosities

The resulting anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings with different macroporosities were determined by using Olympus BX53M.

D. Water Permeability

The water permeability of the resulting anti-adhesion extra thin polyvinyl alcohol foam dressings (PVAETF1, PVAETF2, and PVAETF3) could be determined by following ASTM D4491(standard test methods for water permeability).

III. RESULTS AND DISCUSSION

In this work, a novel anti-adhesion extra thin polyvinyl alcohol foam dressing for NPWT was obtained by using a super clean air-foaming process, which could form foam matrix with fully open cell structure. Open cell structure could be observed by using optical microscopy(Figure II). Furthermore, the structure could provide excellent water permeability, particularly, for NPWT. The water permeability of the resulting anti-adhesion extra thin polyvinyl alcohol foam dressings (PVAETF1, PVAETF2, and PVAETF3) could be observed in the range of 80~88% by using ASTM D4491(standard test methods for water permeability). New anti-adhesion extra thin polyvinyl alcohol foam dressings derived from a super clean air-foaming process were designed for negative pressure wound therapy (NPWT). Preclinical evaluation of new designed anti-adhesion extra thin polyvinyl alcohol foam dressings could be established by determining water morphology, water permeability, macroporosity, mechanical property of resulting samples for providing a excellent potential medical devices in clinic applications.

A. Macroporosities

The resulting anti-adhesion polyvinyl alcohol (PVA) extra thin foam (PVAETF) dressings with different macroporosities in the range of 340 μm~930 μm were obtained such as averaged macroporosity of PVAETF1 with diameter of 348 μm, averaged macroporosity of PVAETF2 with diameter of 473 μm, averaged macroporosity of PVAETF3 with diameter of 921μm as showed in Figure II.

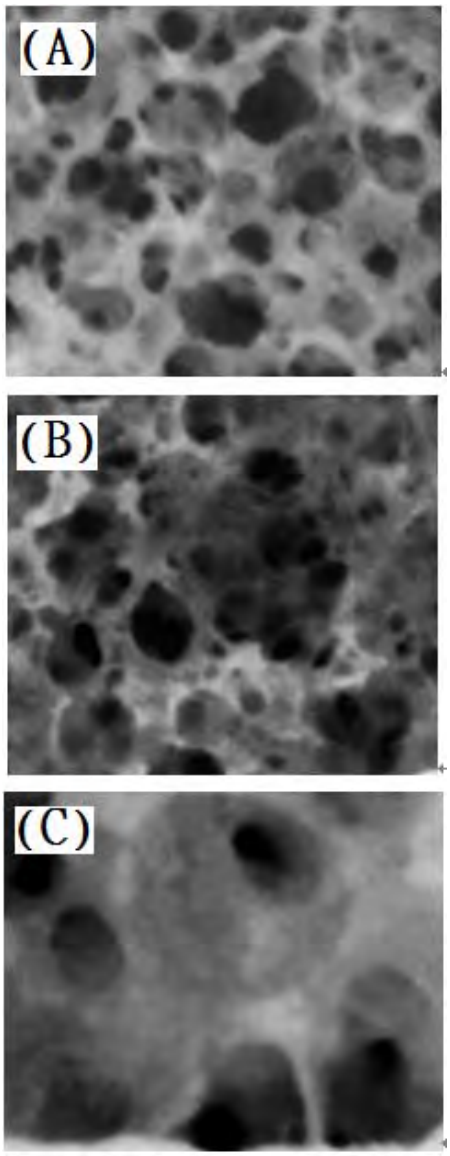

FIGURE II. PHOTOS OF THE RESULTING EXTRA THIN FOAM DRESSINGS FOR NPWT(A)PVAETF1, (B) PVAETF2, AND (C) PVAETF3

B. *Elongation property*

The resulting anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings showed good elongation property such as PVAETF1 with 668% of elongation rate, PVAETF2 with 665% of elongation rate, and PVAETF3 with 360% of elongation rate.(Table I).

TABLE I. MECHANICAL PROPERTY OF ANTI-ADHESION POLYVINYL ALCOHOL (PVA) EXTRA THIN FOAM DRESSINGS

	Elongation at Break (%)	Tensile Strength (kPa)
PVAETF1	668.8	661.9
PVAETF2	665.2	421.7
PVAETF3	360.8	204.3

C. *Clinic Application for NPWT*

The resulting anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings with good anti-adhesion property could be employed to solve the adhesion problems of PU foam dressing for NPWT as showed in Figure III. The anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings could be a kind of contact dressings to provide good anti-adhesion property, water permeability, and mechanical property. It could be a powerful medical device for NPWT. Of course, the other clinic application also could be considered because of their excellent properties.

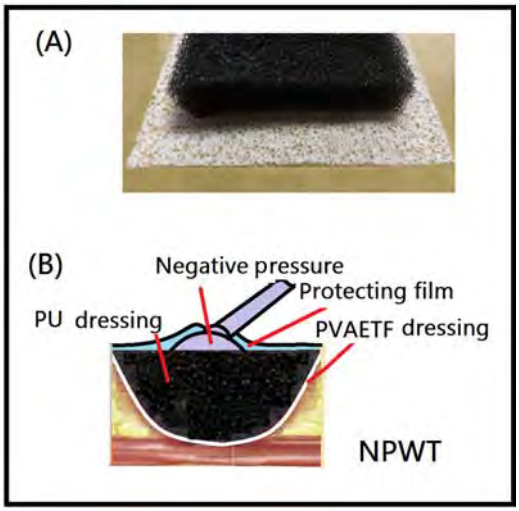

FIGURE III. (A)PHOTO OF ANTI-ADHESION POLYVINYL ALCOHOL (PVA) EXTRA THIN FOAM DRESSINGS(WRITHE ONE WITH AN EXTRA THIN SIZE) SOLVING THE ADHESION PROBLEMS OF PU FOAM DRESSING(BLACK ONE WITH RELATIVE THICK SIZE) FOR NPWT; (B) NPWT APPLICATION[2]

IV. CONCLUSIONS

In this study, a series of new anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings with different macroporosities in the range of 340 μm~930 μm were obtained. The resulting anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings showed good elongation property such as PVAETF1 with 668% of elongation rate, PVAETF2 with 665% of elongation rate, and PVAETF3 with 360% of elongation rate. The resulting anti-adhesion polyvinyl alcohol (PVA) extra thin foam dressings could provide a powerful potential in the clinic application of NPWT and enhance the range of clinic application of NPWT.

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