A New Approach to Radiochemical Sterilization

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Statement of Purpose: Radiochemical sterilization (RCS) has been used successfully in the past few years for the sterilization of absorbable sutures, electrospun fabrics and tissue adhesives.[1-4] Until recently, most of the conducted RCS entailed the use of a combination of 5kGy dose of gamma radiation and polyformaldehyde granules as a source of radiolytically generated formaldehyde. The polyformaldehyde granules were encased in a sealed Tyvek pouch placed in a hermetically sealed package in the vicinity of the subject article. Only a minor fraction of the polyformaldehyde mass underwent radiolytic depolymerization to produce a sterilizing dose of formaldehyde. Although the amount of residual formaldehyde in the package was negligible, a more effective source of formaldehyde was sought. And this led to the pursuit of the present study. The latter entails the use of a mixture of paraformaldehyde and silica gel granules in a sealed porous pouch (denoted Formaprene packet) to provide a highly effective source of formaldehyde, which can also act as a desiccant to absorb trace amounts of moisture in the package. In effect, this reduces the likelihood of undesirable interaction of residual moisture with absorbable sutures or tissue adhesive

Methods: Tyvek® 1059B (DuPont) sheets were cut into about 2 mm width, folded strips and sealed in rows to form pouches with one open end. Aliquots of paraformaldehyde and silica gel particles were mixed at weight ratios of 1:5 and 1:10. The total weight of both components in each pouch was 150 mg. The loaded pouches were sealed to yield pouches measuring about 2 x 2 cm. The Formaprene packets and biological indicator spore strips (Raven Labs, Omaha, Nebraska) containing 1 x 10^6 *bacillus pumilus* CFU (derived from ATCC #27142) were included in each hermetically sealed foil pack to verify that the specified dose of radiation and generated formaldehyde result in a sterility assurance level of 10^{-6}. In this study, the foil packs were irradiated using a gamma radiation dose of 5 kGy. After irradiation, the foil packs were analyzed for residual formaldehyde and moisture content. The residual formaldehyde was extracted by mixing the nitrogen gas in the pack with deionized water. 2,4-Dinitrophenylhydrazine (Aldrich) was used to complex with formaldehyde in the deionized water and its concentration was determined using an established HPLC method.[6] The moisture content was measured using an attachment to allow a continuous dry nitrogen flow through each pack while leading to a DL32 Coulometric titrator. Spore strips were incubated in individual tubes containing premade tryptic soy broth (Raven) at 30ºC for 7 days. Three experimental samples were completed on all the Formaprene groups.

Results: The results for the residual formaldehyde in the irradiated foil packs are summarized in Table I along with a control pack with a pouch containing 150 mg of the previously used, unstabilized Celcon®. Lower levels of residual formaldehyde were measured in Formaprene containing packs compared with the control packs containing Celcon pouches. As expected, lowering the concentration of paraformaldehyde in the Formaprene packets decreased the residual formaldehyde to lower levels while achieving a complete kill of spores as outlined in Table II. In Table III, the desiccant effect of the Formaprene packets is illustrated. Conversely, control packs with Celcon® pouches showed an increase in the moisture content. The new Formaprene packets lowered the moisture content leading to a drier environment in the foil pack.

Table I. Residual Formaldehyde Data for 5kGy-Irradiated Formaprene Packets and Celcon Pouches

Sample Description	Residual Formaldehyde (μg)
1:5 Formaprene Packets	14.57
1:10 Formaprene Packets	7.18
Unstabilized Celcon®*	62.5

*2 samples

Table II. Effect of 5Kg Irradiated Formaprene Packets on Spore Strips

Test Sample	Colony Forming Units (CFU)
Irradiated spore strip without Formaprene	43
Formaprene packets (1:5 paraformaldehyde:silica gel) plus spore strips	0
Formaprene packets (1:10 paraformaldehyde:silica gel) plus spore strips	0
Control (unsterilized spore strips, expected CFUs = 170	166

Table III. Effect of Irradiated Formaprene and Celcon on Moisture Content of Sealed Foil Packs

Sample Name	Water Content (μg)	
	4 wk	14 wk
Control	253	199
Unstabilized Celcon®*	428	458
Formaprene Packets (1:5)	97*	97

*2 samples

Conclusions: The use of the Formaprene packets is a preferred substitute to the unstabilized Celcon® pouch for use in RCS.

References:

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