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Effect of EtO and NO_2 Sterilization on Injection Molded Evolvecomp™ products

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Objectives

The objective of this study was to analyze the effect of two different sterilization methods, NO_2 and ethylene oxide (EtO) sterilization, on investigational interference screw type implants. The analyzed products were composed of a blend of Evolvecomp™ GF40PLD96 and 70L/30D,L PLA (Resomer LR708).

Materials and Methods

Investigational chopped fiber interference screws type implants used in this study were injection molded from Evolvecomp™ GF40PLD96 pellets and 70L/30 D,L PLA (Resomer LR708). The design of the used samples was created by a customer of Arctic Biomaterials and thus it is not opened in this paper. Initial properties of manufactured samples are listed in Table 1.

Table 1. *Initial properties of manufactured implant prototypes.*

Inherent viscosity (dl/g)	Monomer content (wt-%)	Mineral fiber content (wt-%)	Diameter (mm)	Product: Interference screw
2.6	0.07	21 %	12.06	

The implant prototypes were sterilized using EtO and NO_2 sterilization (Table 2). EtO sterilization was outsourced to two independent EtO sterilization providers (EtO-A and EtO-B). NO_2 sterilization was conducted by using Noxilizer.

Dimensions of the implant prototypes were measured before and after each sterilization. 12 weeks *in vitro* degradation study was conducted in order to analyze the effect of sterilization method on the degradation behavior of implant prototypes.

In vitro degradation study at 37°C in simulated body fluid (SBF) buffer solution was done according to standard [3]. During the *in vitro* study, the diameter of implant prototypes, the mass loss, the reduction of inherent viscosity and shear strength retention were measured.

Table 2. *Sterilization cycles used in this study.*

Sterilization method	Temperature	Relative humidity
NO_2	25 °C	40 %
EtO-A	40 °C	35-80 %
EtO-B	35-45 °C	50-80 %

Results

The diameter of each implant prototype was measured before and after sterilization and at each time point on *in vitro* study (Table 3). A slight increase in diameter during the 12 week degradation study was found. This increase was not affected by sterilization method.

Table 3. *Maximum diameter of implant prototypes at each time point during in vitro study.*

Time point (week)	Maximum diameter average (mm)		
	Group NO_2	Group EtO-A	Group EtO-B
non-sterile	12.06		
Sterile 0 (RT)	12.06	12.07	12.05
0 (24 h)	12.08	12.08	12.08
6	12.09	12.09	12.09
12	12.16	12.14	12.15

Table 4 summarizes the results of mass loss analysis. Mass loss analysis was conducted according to [1,2]. Number of parallel samples was 3. Mass loss was not remarkably affected by sterilization method and no remarkable mass loss could be measured during the 12 week follow up.

Table 4. *Mass loss during the 12 weeks in vitro study.*

Time point (week)	Mass retention (%)		
	Group NO2	Group EtO-A	Group EtO-B
0 (RT)	100.00	100.00	100.00
12	99.78	99.30	99.26

Figures 1 and 2 present the effect of NO_2 and EtO sterilization on inherent viscosity and it also summarizes the reduction of inherent viscosity during the *in vitro* study. Inherent viscosity was measured according to [5]. Number of parallel samples was 2. NO_2 and EtO sterilization had no remarkable effect on initial inherent viscosity and the reduction of inherent viscosity during the *in vitro* study was practically identical regardless from chosen sterilization method (NO_2 and EtO) during the 12 weeks follow-up.

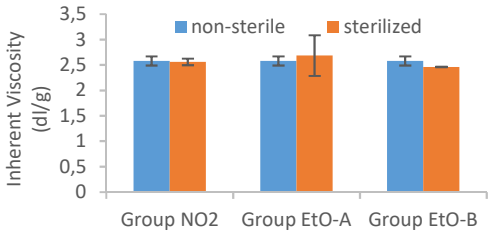

Figure 1. *Effect of NO_2 and EtO sterilization on initial inherent viscosity.*

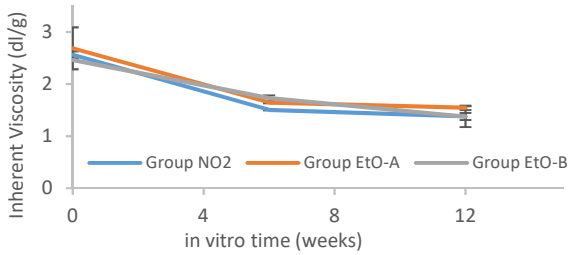

Figure 2. *Effect of NO_2 and EtO sterilization on reduction of inherent viscosity during the in vitro study.*

Mechanical properties of the implant prototypes were determined by a shear test [6]. Figures 3 and 4 summarize the effect of NO_2 and EtO sterilization on initial strength and the strength retention of the implants during the *in vitro* study. Number of parallel samples was 4. Neither NO_2 nor EtO sterilization had remarkable effect on the initial strength. The strength retention was practically identical regardless of chosen sterilization method (NO_2 and EtO) during the 12 weeks follow-up. The observed initial drop in strength during the first 24h of the degradation has been reported also in [7] for similar composite materials. In [7] this initial strength drop was explained to be caused by the basic ions leached out from the mineral fibers which triggered the capillary formation, which further enables the penetration of water inside the implant [7].

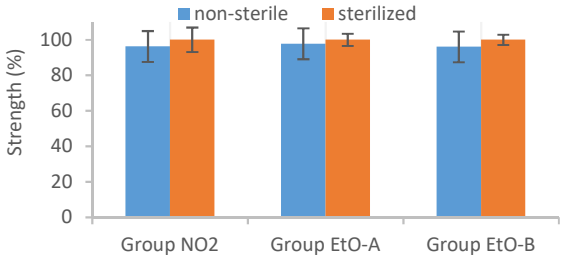

Figure 3. *Effect of NO_2 and EtO sterilization on initial strength.*

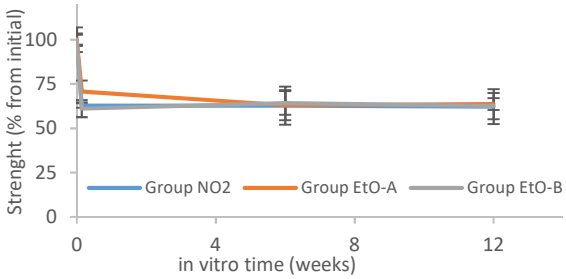

Figure 4. *Effect of NO_2 and EtO sterilization on strength retention during the in vitro study.*

Conclusions

EtO sterilization and NO_2 sterilization had no remarkable effect on analyzed initial properties or on *in vitro* degradation characteristics of investigational chopped fiber interference screws type implants.

References

[1] ASTM F2502-11 Standard specification and test method for absorbable screws and screws for internal fixation implants
[2] FDA Guidance (draft): Guidance document for testing biodegradable polymer implant devices
[3] ISO 23317:2014 Implants for surgery — In vitro evaluation for apatite-forming ability of implant materials
[4] investigational implant prototypes: customer owned data on file
[5] Arctic Biomaterials white paper, data on file
[6] Huttunen M, Kellomäki M. Strength retention behavior of oriented PLLA, 96L/4D PLA, and 80L/20D,L PLA. Biomatter. 2013 Oct-Dec;3(4)
[7] Lehtonen TJ, Tuominen JU, Hiekkanen E. Resorbable composites with bioresorbable glass fibers for load-bearing applications. In vitro degradation and degradation mechanism. Acta Biomater. 2013;9(1)
[8] Cao XY, Tian N, Dong X, Cheng CK, Polylactide Composite Pins Reinforced with Bioresorbable