

Ethylene Oxide Sterilization of Medical Devices



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Introduction

Ethylene Oxide (EO) is a well known sterilizing agent. However, only recently has its use significantly emerged, based on its range of applications in the field of new medical device development and sterilisation. Advantages of this sterilization technology over other industrial sterilization technologies are addressed with the purpose of explaining why EO, despite many predictions about its demise as a sterilization alternative, is still a dominant mode of sterilization and continues to be used for increasing volumes of MDs. An overview of the progress, in terms of EO sterilization optimisation is analysed and issues, such as parametric release, lethality modelling and EO diffusion modelling, are discussed. Emphasis is given to a critical analysis to allow the definition of optimal microbiological inactivation conditions and, consequently, a continuous increase of process flexibility without compromising safety. The scientific community should also focus on other important issues, such as EO diffusion in different substrates, taking into account different environmental conditions along both sterilization and aeration.

Objective

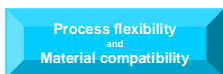
Provide an accurate reflection on ethylene oxide (EO) sterilization of medical devices (MDs) - a promising field to explore and develop.

EO STERILISATION

Advantages



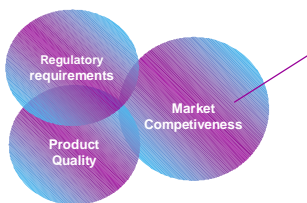
- § exceptional penetration properties of EO;
- § exceptional bactericidal, sporicidal and virucidal properties of EO;



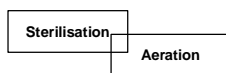
- § large number of possible control variables;

EO has allowed and contributed significantly to the advancement and revolution of delicate, complex and sophisticated MDs, that otherwise would not be viable due to the fact that for given sensitive materials EO is the only acceptable sterilisation method. ^{1,2,3,4,5}

Process Optimisation



- § Cost effectiveness;
- § Flexibility;
- § How to short as possible overall sterilisation process time?



- § Implementation of **parametric release** simply eliminates the microbiological test phase from routine;
- § **Validation of aeration process** allows assessment of EO residues in compliance with the requirements of ISO 10993-7;
- § Improvements in process design through **lethality modelling / diffusion modelling**;

Direct measurement of key process variables, as well as improvements in process design achieved through scientific modelling and experimental evidence, allows development of each process phase and consequent reduction in an overall sterilisation process time. ⁶

References

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Lethality modelling

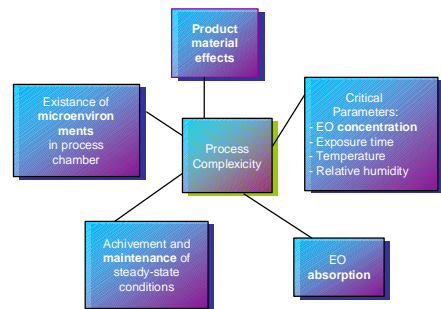
Mathematical models are essential for designing ethylene oxide sterilisation processes. Optimisation and validation of the different methodologies are a requirement. ^{5,6,7,8}

Predicting accurate D-values

Definition of optimal microbiological inactivation conditions

- Cycle time and/or EO concentration reduction;
- Effectiveness and equivalency comparison of different sterilization processes;

The process gain in terms of efficiency and flexibility, and the industry movement towards **parametric release**, is much more scientifically supported.



Integrating EO Concentration and Temperature

$$F_{C_R T_R} = \sum_{i=1}^n F_i = \sum_{i=1}^n \frac{z}{C_i} 10^{\frac{z}{z} \log \frac{T_i}{T_R} + \frac{1}{z} (T_i - T_R)} \frac{C_i}{C_R}$$

- Where,
- C EO concentration
 - F Equivalent process time; Exposure time at T_R and C_R that would cause the same lethal effect as the $T(t)$ and $C(t)$ temperature regimes
 - i Process step, for which the EO concentration and temperature are constant
 - n Total number of process steps
 - R Reference
 - T Temperature
 - t Time
 - z Temperature increase required to reduce the decimal reduction time (D-value) by 90%

EO diffusion modelling

The study of EO diffusion from the steriliser headspace to the articles, and through the articles, is a challenge matter

Objectives:

- § Definition of the specific relationship between EO concentration and process lethality ;
- § Efficiency comparison between different aeration methodologies;
- § Prediction of the dynamic distribution of EO concentration within the load;

Final Remark

Once the modelling of accumulated lethality, as well as the modelling of EO diffusion in different matrices, is a perfectly apprehended matter, an overturn in the way of designing, validation and routine control of the EO sterilisation process will occur.

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