1. BIOCIDES IN THE HEALTHCARE ENVIRONMENT

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Sponsored by JohnsonDiversey (www.johnsondiversey.com)

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2. LECTURE OVERVIEW

- Background
- Definitions
- Usage of biocides in the healthcare environment
- Factors affecting the efficacy of biocides
- Biocides use, misuse and consequences
- Conclusion

3. OBJECTIVES

- Understand the use of biocides in the healthcare environment
- Understand the factors influencing biocidal activity
- Review the important types of biocide and some of their usage

4. RATIONALS FOR USING CHEMICAL BIOCIDES

- The control of micro-organisms is of prime importance in hospital and industrial environments but also in domiciliary environment
- In hospital there is the additional consideration of patient care
  - protection from nosocomial infection
  - prevention of cross-infection
- Preservation of pharmaceutical preparations
  - prevention of microbial spoilage
  - minimising risk of consumer/patient acquiring an infection

5. DEFINITIONS

- DISINFECTION
  - removal of micro-organisms including pathogenic ones from the surfaces of inanimate objects
  - not necessary the destruction of all micro-organisms but the reduction of micro-organisms to an acceptable level
- ANTISEPSIS
  - destruction or inhibition of micro-organisms on skin and living tissue
- CLEANING
  - removal of all foreign material (e.g., soil, blood)

6. DEFINITIONS

- PRESERVATION
  - prevention of microbial spoilage of products and decreasing risk of infection when the preparation is administered
  - preservatives should prevent the proliferation of micro-organisms in non-sterile products
  - preservatives should kill micro-organisms in sterile products
- STERILIZATION
  - complete elimination of micro-organisms including bacterial spores
  - sterility – “the absence of viable micro-organisms”
Biocide Use in the Healthcare Environment

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7 BIOCIDES USAGE IN THE HEALTHCARE ENVIRONMENT

- **HIGH-RISK**
  - high-level disinfection
  - contact with sterile body area
  - critical items

- **INTERMEDIATE RISK**
  - intermediate-level disinfection
  - contact with mucous membranes
  - contamination with virulent/transmissible organisms
  - semi-critical items
  - highly susceptible patients

- **LOW RISK**
  - low-level disinfection (cleaning and drying)
  - contact with intact skin
  - non-critical items

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8 BIOCIDES USAGE IN THE HEALTHCARE ENVIRONMENT

MAIN WANTED CHARACTERISTICS

- Antimicrobial activity
  - broad spectrum
  - rapid activity
  - retain stability / pH
  - retain stability / TC
  - retain activity OL / HW
  - retain activity / dilution
  - residual activity

- Safety
  - low toxicity
  - degradable

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9 BIOCIDES USAGE IN THE HEALTHCARE ENVIRONMENT

MAIN WANTED CHARACTERISTICS

- Formulation and usage
  - no or low corrosiveness
  - no odour
  - non staining
  - good wetting and detergency
  - easily combined with liquid or powder
  - compatible with other chemicals
  - cost-effective

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10 BIOCIDES PROPERTIES

- INACTIVATION KINETIC

  Graph showing Number of viable cells vs. Time

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11 BIOCIDES PROPERTIES

- INACTIVATION KINETIC

  Graph showing log number of viable bacteria vs. Time

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12 FACTORS INFLUENCING EFFICACY IN PRACTICE

- Several factors affect the efficacy of disinfection
  - concentration
  - contact time
  - temperature
  - pH
  - organic load
  - organisms
  - ‘conditions’
  - formulation

- Their practical significance for the end-product and its usage is rarely discussed
FACTORS INFLUENCING EFFICACY

IN PRACTICE

CONCENTRATION

- An effective concentration is needed
- Concentration depends on
- Effective concentration
- Failure to be aware of the 'concentration' factor

FACTORS INFLUENCING EFFICACY

IN PRACTICE

CONCENTRATION

- safety
- biocide (type)
- usage
- reduce microbial load to a 'safe' level
- improper usage
- misleading claims

FACTORS INFLUENCING EFFICACY

IN PRACTICE

CONCENTRATION

- phenol has a concentration exponent of 6
- its activity reduced by the power of 6 upon dilution
- two-fold dilution means a decrease in activity of $2^6 = 64$
- use of effective and safe concentrations of biocides
- evaluation of biocidal activity
- effective quenching (neutralisation) of biocides

FACTORS INFLUENCING EFFICACY

IN PRACTICE

CONTACT TIME

- The period of treatment is important
- No straight relationship with concentration
- Length [duration] of survival

FACTORS INFLUENCING EFFICACY

IN PRACTICE

TEMPERATURE

- Temperature efficacy relationship ($Q_{10}$ value)
- phenol 4
- butanol 28
- ethanol 45
- ethylene glycol mono-ethyl ester 300

FACTORS INFLUENCING EFFICACY

IN PRACTICE

CONTACT TIME

- The period of treatment is important
- compliance
- hand washing
- “sterilization”
- Manufacturers
- No straight relationship with concentration
- longer contact time = better efficacy
- Length [duration] of survival

FACTORS INFLUENCING EFFICACY

IN PRACTICE

TEMPERATURE

- Practical meaning
- $Q_{10}$ for phenol is 4
- a 10°C decrease in temperature reduces the activity by a factor of 4
- Practical applications
- activity upon storage (preservative)
- enhanced activity (combining heat + biocide)
FACTORS INFLUENCING EFFICACY IN PRACTICE

pH

- A change of pH affects biocide activity and micro-organisms
- pH affects the degree of ionization (acid or base)
  - if the active species is the non-ionized molecule:
    - phenols, acetic acid, salicylic acid
    - increase pH = decrease activity
  - if the active is the ionized molecules:
    - dyes
    - increase pH = increase activity

Stability of the molecules
- thiomersal (degradation pH<7)

Usage
- glutaraldehyde

Micro-organisms
- surface charge
- growth

FACTORS INFLUENCING EFFICACY IN PRACTICE

pH

- Increasing activity as pH rises
  - QACs
  - chlorhexidine
  - diamines
  - amines
  - triphenylmethane dyes
  - glutaraldehyde

- Competition with H+ for anionic sites

- increase in degree of ionization compounds and changes in bacterial surface groups

- active factor is the un-dissociated molecule

- increased dissociation of molecule

- dissociated molecule makes only a minor contribution to antimicrobial activity

- active factor is the un-dissociated molecule

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ORGANIC MATTER (INTERFERING SUBSTANCES)

- Interfering substances decrease biocide activity (blood, pus, soiling, milk, etc.)
  - decreasing amount available (absorption)
  - protection

- Practical applications
  - cleaning process
  - biocide properties

- some biocides may exert a detergent action
- some detergents may exhibit some biocidal activity
FACTORS INFLUENCING EFFICACY

INOCULUM SIZE AND TYPES OF MICRO-ORGANISMS

- Extent of microbial contamination is important
  - higher concentrations
  - longer contact time

- Different micro-organisms have different susceptibility to biocides
  - prions
  - bacterial spores
  - protozoal oocysts
  - mycobacteria
  - naked viruses
  - protozoal cysts
  - vegetative Gram-
    - fungi
    - protozoa
  - vegetative Gram+
  - enveloped viruses

INOCULUM SIZE AND TYPES OF MICRO-ORGANISMS

- Practical applications
  - extent of microbial contamination difficult to assess
  - should represent the worst case scenario
  - in laboratory-based inactivation experiments, the inoculum size should be controlled and clearly stated
  - highly infectious or virulent micro-organisms should be eliminated
  - Hepatitis B virus
  - E. coli O157

MICROBIAL GROWTH CONDITIONS

- The association of bacteria with solid surface leads to the formation of biofilms
  - less sensitive to disinfection
  - low metabolism
  - dormant cells
  - penetration
  - biofilm phenotype

- Biofilms and resistance
  - catheters
  - heart valves
  - implanted ocular lenses
  - intrauterine devices

- Biofilms and infections
  - physically conditions
  - chemical conditions
  - suspension vs. biofilm

- Practical significance
  - highly resistant microbial communities
  - testing protocols

‘CONDITIONS’

- Surface
  - porous
  - non-porous
  - animate

- Practical significance
  - reduction of adhesion
  - ‘facilitated’ disinfection

- Water activity
  - gaseous disinfectants
  - ethylene oxide, ß-propiolactone, formaldehyde

- Relative humidity
  - neutralisation

- Incompatibility
  - preparation of disinfectants
  - pre-humidification

- Practical significance
  - hard water
  - divalent cations

- Relative humidity
  - gaseous disinfectants
  - ethylene oxide, ß-propiolactone, formaldehyde

- Incompatibility
  - neutralisation

- Practical significance
  - preparation of disinfectants
  - pre-humidification
  - knowledge of product

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FACTORS INFLUENCING EFFICACY

FORMULATION

SURFACE ACTIVITY

- Surface activity and biocide efficacy
- Practical significance

- Surface active agents
- Potentiation of activity
- Delivery of active
- Incompatibility

If you have any questions or need further assistance, please feel free to contact me at paul@webbertraining.com.

BIOCIDES USAGE IN THE HEALTHCARE ENVIRONMENT

LIMITATIONS

- Toxicity
- Alteration of the surface/equipment
- Incompatibility with other components of a formulation
- Overall efficacy against a given predicted micro-organism

- End user
- Environment
- Corrosiveness
- Colour formation

BIOCIDES USAGE IN THE HEALTHCARE ENVIRONMENT

HIGH-LEVEL DISINFECTION

- Aldehydes
  - glutaraldehyde
  - ortho-phthalaldehyde
  - formaldehyde

- pH >7
- Soiling
- Non corrosive
- Toxic
- Fumigation

INTERMEDIATE/LOW-LEVEL DISINFECTION

- Biguanides
  - chlorhexidine
  - polyhexamethylene biguanide (contact lenses)

- pH >7
- Soiling
- Incompatible with soap and anionic detergents
- Inactivated by hard water, some materials and plastic
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#### Biocides Usage in the Healthcare Environment

**Intermediate/low-level disinfection**

- Quaternary ammonium compounds (QACs)
  - cetrimide
  - pH > 7
  - soiling
  - incompatible with soap and anionic detergents
  - absorbed by rubber/plastic
  - absorbed by fabric

- Halogen realising agents (HRAs)
  - iodine
  - pH > 7
  - soiling
  - staining
  - may corrode metals
  - long term toxicity

- Phenolics
  - triclosan (fabrics, surface)
  - pH > 7
  - soiling
  - activity greatly reduced by dilution
  - absorbed by rubber/plastic

- Alcohols
  - soiling
  - poor penetration
  - good cleansing properties
  - combination

#### Antisepsis

- Phenolics (triclosan)
- Alcohols
- Biguanide (chlorhexidine)
- QACs
- Iodine (povidone iodine)
- CRAs (hypochlorites)
- Hydrogen peroxide
- Aldehyde (glutaraldehyde)
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BIOCIDES USAGE IN THE HEALTHCARE ENVIRONMENT

PRESERVATION
- Acids and esters (parabens)
- Biguanides
- QACs

USE AND MISUSE
- Inappropriate disinfection regimens
  - inappropriate concentrations
  - incompatibility
  - absorption
  - microbial survival
  - contamination
  - infection
  - resistance
- Failure of a disinfection process
  - non-respect / no understanding factors affecting activity
- Overuse
  - systematic disinfection of low-risk surfaces
  - incorporation into fabrics and surfaces
  - concentrations?
  - commercial benefit

CONCLUSION
DISINFECTION IN THE HEALTHCARE ENVIRONMENT
- Appropriate usage
- Understanding factors affecting activity
- Training of end user
- Respect of manufacturer’s instructions
- Compliance
- ESSENTIAL
  - prevention
  - training
  - documentation
  - appropriate testing
  - training

FURTHER READING

Other 2005 Teleclasses
For more information, refer to www.webbertraining.com/schedule.cfm
- March 24 - Infection Control and Pre-Hospital Care with Margaret McKenzie
- March 31 - Voices of CHICA (a free teleclass)
- April 7 - Root Cause Analysis for the Infection Control Professional with Dr. Denise Murphy
- April 14 - Disinfectants and Environmental Impact with Dr. Franz Daschner
- April 19 - Methods for Testing Hand Disinfectants with Dr. Manfred Rotter

Questions? Contact Paul Webber paul@webbertraining.com