Bio-static surface protection:
the next step towards improved infection control

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Background

In response to alarmingly high infections rates and consequent mortality of patients admitted to selected intensive care units of a tertiary care hospital, clinical characteristics were combined with environmental investigations, and a high correlation was found between the causative multidrug-resistant strains and mixed-community biofilms occurring in selected 'hot spots' in these units (Fig 1, Hota et al., 2009).

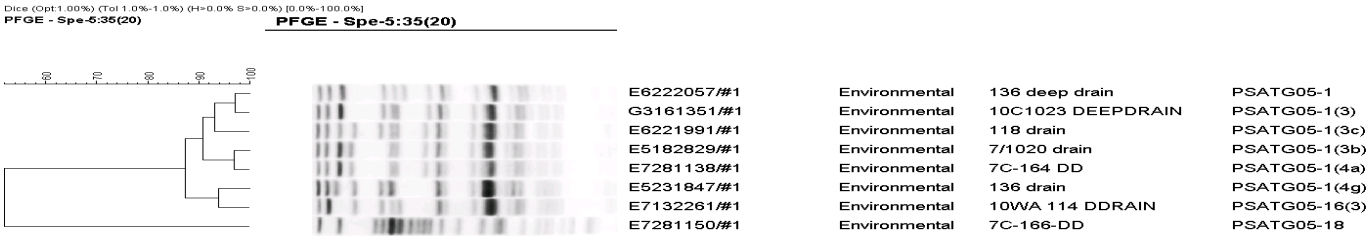


Fig 1. Banding patterns determined by pulsed-field gel electrophoresis and a dendrogram showing the genetic relatedness of isolates of multidrug-resistant Pseudomonas aeruginosa recovered from different patients and environmental sites. These communities showed a remarkable ability to rapidly recover after biocide treatment and follow up studies showed that pathogenic bacteria effectively integrate into environmental bacterial communities (Fig 2A), where they have improved protection against antimicrobials (Fig 2B).

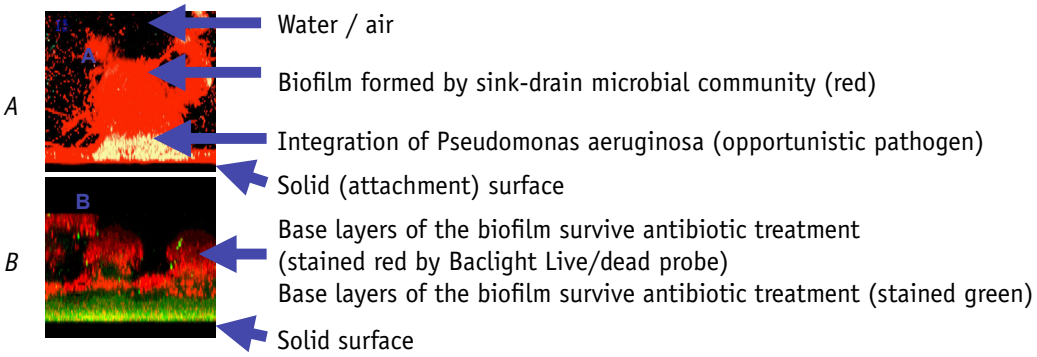


Fig 2. Cross sections of biofilms performed with scanning confocal laser microscopy showing (A) that environmental biofilms provide a habitat for pathogens to proliferate, and (B) where they show notable protection against antimicrobials.

An approach common to most infection control strategies is to routinely clean and apply disinfectants to inhibit or kill unwanted microbial cells. Because of their adaptable nature and rapid growth rate, bacteria can recover and grow back to unacceptable high numbers during intervals between cleaning (Fig 3). The problem is compounded when areas are missed during cleaning or if disinfectants are not allowed sufficient time to effectively inactivate the cells. The small size of bacterial cells compared to the micro-architecture of even polished surfaces greatly contribute to this problem (Fig 4). As shown in Fig 2, once allowed to form biofilms, the cells show increased resistance to antimicrobials. This phenomenon is widely recognized in literature (e.g. Costerton and Anwar, 1996). Perhaps of more serious concern is that prolonged exposure at sub-killing doses leads to antimicrobial resistance. Notably, despite intensified efforts to address this problem, very little progress has been made; e.g. although the European Union's attention to the problem of antibacterial resistance will soon reach a 10-year mark, the rates of resistance in both Gram-positive and Gram-negative bacteria are still increasing (Lode, 2009).

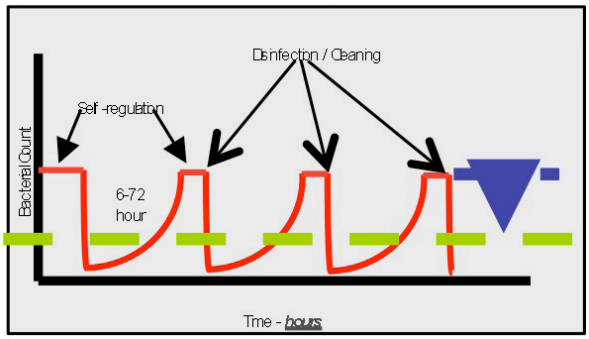
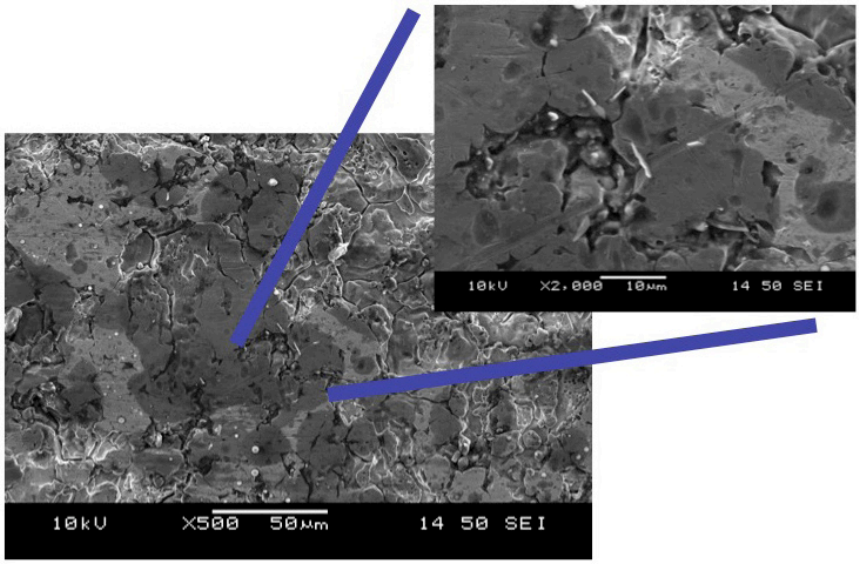


Fig 3. A schematic representation of bacterial survival on environmental surfaces. The red line shows cell recovery after cleaning and disinfection. The extent and rate of cell accumulation depends on various factors, including moisture and available nutrients, to which the bacteria respond by regulating activity and growth rate. The blue dotted line shows the theoretical maximum to which cells can accumulate in a given environment. Infection control programs should aim at lowering this threshold (blue arrow). Surface-active microbial inhibitors can potentially be an important means to achieve this.

Fig 4. Scanning electron micrographs to demonstrate the uneven nature of surfaces that need to be disinfected. Shown here is stainless steel; due to their small size (bacteria are often less than 1 µm in diameter) cells inside these micro-crevices are often our of reach of mechanical removal as well as chemicals applied to the surface. Nano-technology, including 'smart materials' with inherent antimicrobial properties and protective antimicrobial coatings show much promise in this regard as they prevent the establishment of bacterial micro-colonies.



AM500: An alternative approach for infection control

Why the need for alternative strategies?

- The efficacy of standard cleaning chemicals is short-lived
- Chemicals therefore require frequent application
- Microbes rapidly adapt, evolve and multiply
- Repeat usage of conventional chemicals at sub-lethal dosages or ineffective reach may lead to a greater the risk of bacterial mutation
- Bacterial counts can return to previous levels within 4 to 6 hours after cleaning and disinfection

AM500

- Is one of a very few commercially available alternatives to chemical-based microbiological cleaning
- Is safe for humans and animals and highly effective
- Avoids "superbug" mutation as there is no chemical interaction with microbes
- Lasts for 60+ days; chemical alternatives last 20 minutes
- Can be used virtually anywhere, on any surface
- Does not involve leaching technology or heavy metals
- Is EPA registered and USDA accepted

How does it work?

- Forms a nano-scale biostatic layer on treated surfaces
- Through self assembled layers (see Fig 4) forms an almost permanent bond with the surface
- This results in a dense field of carbon shafts projecting from the surface
- Bacterial cells are drawn to the positively charged nitrogen ends of the shafts (Fig 5)
- A positive charge on the nitrogen end interacts with the net negative charge on the bacterial cell

This interaction disrupts the cell membrane, leading to leaking of cytoplasmic content and the cell's ability to regulate osmotic potential, which leads to cell death.

Inactivation is thus the result of a physical, NOT chemical interaction.

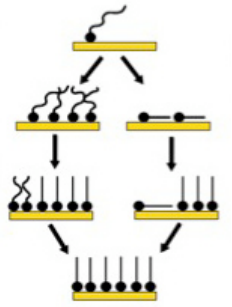


Fig 5. Self assembled layers: the active ingredient attaches to all available bonding sites, leaving a 'forest' of molecules that extend from the surface, preventing adhesion of microbes at interface, and in the case of AM500, disrupt membrane function which causes cell death.

Benefits

- Reduces risk and cost by preventing microbial growth on surfaces over extended periods
- By treating surfaces of all types, personnel benefit from reduced exposure to harmful microorganisms, with reduced staff absenteeism through illness
- Reduced person-to-person transfer
- Reduced environment-to-person transfer
- Reduced risk of product contamination and thus product recall or litigation
- Widely applicable:
  - Hi-touch points (e.g. door handles, desks, visitor seats, AC ducting, carpets, food preparation areas)
  - Surfaces not cleaned regularly and effectively are potential reservoirs for health-damaging bacteria

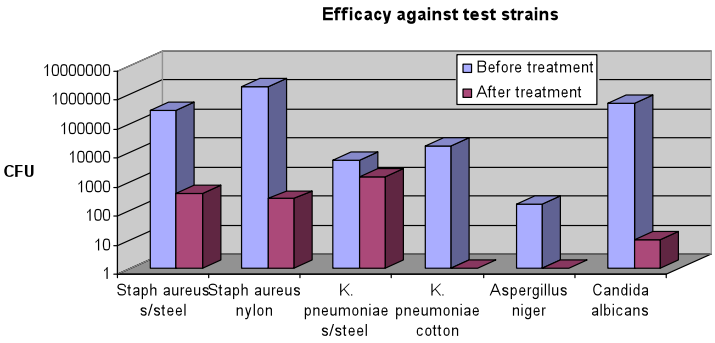


Fig 6. Typical laboratory results showing inhibition efficiency against test strains. Similar results were obtained with E.coli. The efficacy against K. pneumoniae (only 74% reduction) can potentially be ascribed to the micro-topography of this metal, as shown in Fig 4.

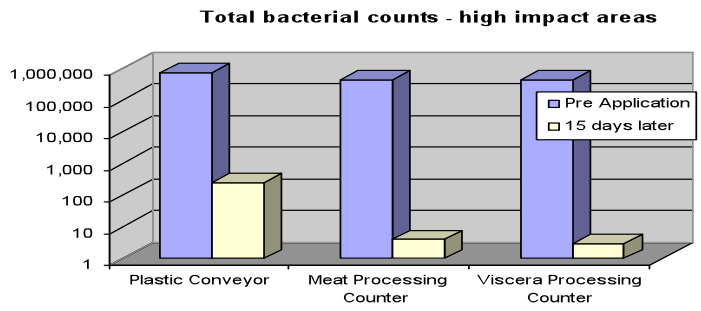


Fig 7. Typical results showing inhibition efficiency against naturally-occurring microorganisms: in this case in a food processing area.

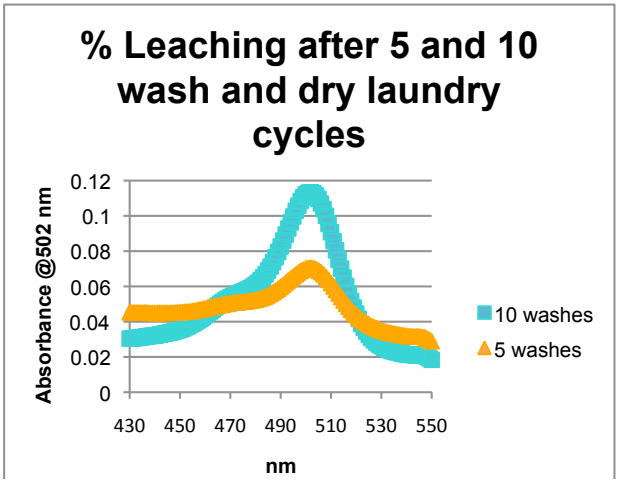


Fig 8. AM500 showed remarkable binding strength and stability even after repeated wash cycles in an industrial laundry facility. The percentage loss of the molecule was calculated to be on average 0.106% / wash cycle or 0.53% after 10 cycles.

Conclusions

The results showed that inhibition of bacterial colonization of surfaces is possible with a relatively simple treatment. Such prevention, rather than reactive treatment of existing biofilms should be implemented wherever feasible. While it is mostly impossible to have a 100% prevention of bacterial surface colonization with any of the inhibitors currently available and safe for use in clinical settings (including silver coatings and 'smart materials'), incorporating inhibitors with existing cleaning procedures should greatly improve efforts to mitigate infection. Because of its ease of application, cost effectiveness and demonstrated inhibition efficacy, AM 500 shows much potential in this regard.

References

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