Field based multiplex detection of biothreat agents using electrochemical biochip technology

Introduction

Due to the potential risk of terrorist attacks using highly toxic or pathogenic biothreat agents (bacteria, viruses and toxins) there is a need for rapid, sensitive and specific detection of all kinds of biothreat agents in the field. In general, nucleic acid based detection platforms are applied for pathogen detection. However, PCR is unable to detect proteinaceous toxins and requires a clean sample demanding elaborate sample preparation. In contrast, immunoassay based technologies offer the possibility for universal detection of bacteria, viruses and toxins.

Methods

pBDi platform:

- Biochip based detection platform
- Integrated in a robust suitcase for use in the field by first responders (Fig. 1 A)
- Based on an automated electrochemical sandwich-ELISA (Fig. 1 B)
- Capture antibodies against specific biothreat agents are immobilized on electrodes of a biochip (16 interdigitated gold electrodes)
- Multiplex detection of up to 6 biothreat agents within 20 minutes
- Inherent positive and negative control
- Very sensitive due to strongly amplified electrochemical detection system including a redox cycling process of enzyme product between interdigitated electrode structure (Fig. 1 B)
- Fully automated fluidics
- Software controlled data analysis applying a ruggedized tablet PC via USB or Bluetooth connection

Biochips: Four different biochip panels detecting each up to six biothreat agents in parallel including inherent positive and negative control electrodes are available (Tab. 1). Furthermore, biochips for site-specific immobilization of customer antibodies are available.

Results

- pBDi is usable in the field by first responders using personal protective equipment (Fig. 2).
- pBDi was evaluated by German and French fire fighters using 20 unknown samples containing varying amounts of toxin or bacteria in buffer or various sample matrices, respectively. pBDi identified all 20 unknown samples correctly.
- pBDi shows excellent limit of detections (LODs) for rapid multiplex detection of bacteria, orthopoxvirus and toxins (Tab. 1).
- Specificity of biochip detection is demonstrated applying different amounts of bacteria or Vaccinia virus, respectively (Fig. 3).
- Demonstration of assay robustness detecting ricin or F. tularensis, respectively, in sample matrices with high recovery rate (Fig. 4).

Conclusions

- Biothreat agents analysis in approx. 20 minutes with an automated procedure
- Parallel detection of up to six biothreat agents including positive and negative control
- Portable and vehicle integrable due to specific suitcase design
- Excellent sensitivity
- Extendable to new agents

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