



Technology

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FOCUS

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INDIGENOUS DEFENCE TECHNOLOGIES FOR CHEM-BIO DEFENCE

Armed Forces whether Army, Navy or Air Force, deployed at various frontiers of the country, are vulnerable for exposure to microorganism and hazardous chemicals. More so, these agents have potential for use under any given circumstances and environment causing harm to Armed Forces, not alone to physical health, but mental health as well. Defence Research and Development Establishment (DRDE) Gwalior, established in 1973 as an independent laboratory under DRDO has been given the vision and mission "to design and develop state-of-the-art technologies and products for chem-bio defence as well as to establish state-of-the-art repository and testing and evaluation facilities for developed products" to make the country self-reliant in relation to chem-bio defence.

The threat perception of exposure to microorganism and hazardous chemicals is not confined to armed forces and para-military forces only but possesses potential dimension to adversely affect civilian population as well. The chem-bio defence needs detection of microorganism and hazardous chemicals at the earliest, protection from these and decontamination. DRDE has developed state-of-the-art technologies for detection of microorganism and hazardous chemicals by developing chemical sensors, molecular markers/kits and other quick detection techniques, various protective measures and technologies for physical, chemical and medical protection and decontamination of soldiers. All these measures have been widely tested, both in laboratory & in the field.

Keeping in view the above mentioned scenario of threat perception, DRDE, Gwalior has been entrusted the task of development of products and technologies for detection, protection and decontamination against microorganism and hazardous chemicals to protect not alone the armed forces and para-military forces but civilian population as well in addition to disease vector management and bioremediation of human waste at high altitude area and plains. The major objective of DRDE is to make country secure for chem-bio defence in the event of any chemical and biological emergencies. In this issue of *Technology Focus*, Products and Technologies developed by DRDE has been included.



Defence Research & Development Establishment, Gwalior is a key laboratory of life science cluster mandated to design and develop state-of-the-art detection and

protection technologies against hazardous materials and microorganism. Having chemical & biological defence as its thrust area, DRDE has evolved into a centre of excellence with proficiency in detection, protection & decontamination of chemical & biological agents. A large number of technologies & products have been developed for chem-bio defence and majority of them have already been inducted into the Services.

Over the past few years, DRDE has developed core competence in several areas including synthesis, evaluation and process development of toxicants and antidotes, development of chemical and biological sensors, molecular and immunological detection techniques, vector management and bioremediation of organic waste. Besides, DRDE imparts advance training on NBC emergencies to military & paramilitary forces.

Water Testing Medium

Water testing medium is used for testing of a potable water sample for detection of contamination by microorganism. The kit/ bottle contains dried medium which supports bacterial growth when water sample, to be tested, is poured on it. After overnight growth at 30°C to 37°C if the colour turns black, the water sample is unfit for drinking purposes.

Technology of this product has been transferred to private firms for bulk production and the water testing kit is commercially available.



From the Desk of Guest Editor

DRDE has developed biodigester technology for biodegradation of human waste at high altitude areas. Subsequently, this technology has been extended to civil sector and Indian Railways for waste management. Till date, several thousand digesters have been installed for services, civil population & railways in various areas of the country ranging from Siachin Glacier to Lakshwadeep. Thus, DRDE is contributing significantly in *Swachh Bharat Abhiyan*.

DRDE's efforts have not remained confined upto development & demonstration of technology alone, but got success in transfer of several technologies to private entrepreneurs for development of very useful products both for service & civil application. This technology focus is a glaring example of metamorphosis of R&D into technology & products blooming for benefit & fruitful application for armed forces & mankind.

I hope that this issue of *Technology Focus*, which is based on DRDE activities, will be useful and informative to the readers.

Dr. Lokendra Singh
OS & Director
DRDE, Gwalior

Water Poison Detection Kit

Detection of toxic chemical agents is required not only in environmental samples but also in water samples as the terrorists or enemy countries also can sabotage the water supplies.

In order to check the potability of the water streams, ponds, sources, etc., a poison testing kit is required to monitor the water poisons and chemical warfare (CW) agents. Waterpoison detection kit is a manual detection device that can detect poisons and chemical warfare agents in water based on specific chemical reactions with impregnated substrates and reagent papers



that impart specific colour change. It's importance is evident due to the fact that many countries have developed the water poison detection kit. The kit is highly useful in the pre- and post-chemical warfare scenarios. This kit has been evaluated by Services and bulk produced for the Services. The indigenously developed kit is economical. It is a step towards self-reliance. This is inducted into the Services.

Technology of this product has already been transferred to industries for bulk production and the Armed Forces are using this product.

Three-Colour Detector Paper

Detection of chemical warfare agents can be accomplished using manual and instrumental detection equipment. Three-colour detector (TCD) paper, very important NBC defence item, is a manual detection device and can detect aerosol and droplets of chemical warfare agents based on colour change. It's importance is evident due to the fact that many countries have developed the TCD paper. DRDE also developed, trial evaluated by Services, bulk produced for the Services and the technology has been transferred to the industries. The indigenously developed three-colour detector paper is on par to product of imported origin and very economical as it is five times less costly than the imported one. It is the best example of self-reliance. An appreciable foreign exchange, to the tune of 10 crores approximately, has been saved to the exchequer.



This product is inducted into the Services.

Portable Gas Chromatograph

Portable gas chromatograph is an instrument that can be used for the detection of chemical warfare vapours present in the environment. Being chromatogram technique it takes approximately 10 min for a complete analytical cycle. Therefore, it is always to be used in conjunction with early warning systems like GID-3, AP4C, etc. It can detect nerve and blister agents.

Technology of this product has already been transferred for bulk production and the Armed Forces are using this product.



Nerve Agent Detector

This detector works on the principles of electrochemistry and comprises three units. The sensing is carried by an electrochemical cell. An electrolyte is pumped into the electrochemical cell by a peristaltic pump. Contaminated air is drawn into the detector by a membrane pump. The electrolyte contains an organic oxime that reacts with sarin, soman, tabun and Vx and produces cyanide. The generated cyanide causes a potential difference between the working electrode and the reference electrode, which is measured with an electronic circuit. This detector gives both the audio and visual alarms. It has been tested for various interferences like room spray, solvents and automobile exhaust. The instrument has been incorporated with



self-priming mechanism, self-checking mechanism, and microprocessor-based electronics.



This product is used for detection of nerve agents like sarin, soman, tabun, Vx, Phosgene, and Hydrogen cyanide. Technology of this product has already been transferred for bulk production and the product is being used by special protection group for security of VVIPs.

Residual Vapour Detection Kit

Detection of chemical warfare agents can be accomplished using manual and instrumental detection equipment. Apart from three-colour detector (TCD) paper, residual vapour detection (RVD) kit is also a manual detection device that can detect vapours of chemical warfare agents based on specific chemical reactions with impregnated silica gel that imparts specific colour change. It's importance is evident due to the fact that many countries have developed the



RVD kit. The kit is highly useful in the pre- and post-chemical warfare scenarios. The developed kit has been trial evaluated by Services and bulk produced for the Services. Its technology has been transferred to the industry. The indigenously developed RVD kit is on par to the product of imported origin and very economical as it is five times less costly than the imported one. It is a step towards self-reliance.

This product has been inducted into the Services.

Mobile Contamination Analysis Station

The modular labs are basically 'self-contained analytical lab facility on wheels' with the state-of-the-art analytical equipment to analyse and identify the NBC agents in the environmental and clinical samples collected by a NBC Recee vehicle. The labs are equipped with NBC ventilation system, air conditioning system, provision for decontamination, GPS, onboard electrical power supply and a state-of-the-art communication system for initiating NBC countermeasures. All the three labs are having shock-proof installation, CCTV monitoring, effluent drainage system, and drinking water facility.



In case of any nuclear, biological or chemical threats, Recee vehicle will collect the sample from the hot zone and transfer the sample to mobile lab. Mobile lab will analyze the sample and send the report to the respective lab. By doing so, one can minimize the time of response and also casualty.

First Aid Kit CW Type A Mark-1

DRDE has developed “First Aid Kit CW Type A Mark-I (FAK-A)”, one of the deliverables under NBC programme. Exposure to nuclear, biological, and chemical (NBC) agents may occur as a surprise, and before detection and physical protection, individual may be exposed to the extent-dangerous for him. Hence, medical countermeasures have to be given in the form of first aid, either by self or by the companion. FAK-A developed, has also been revised/upgraded by addition/replacement of new drugs with removal of old/obsolete ones, for treatment of more effective poisoning chemical, nuclear, and biological warfare agents. It also contains custom-made medicines.



The FAK-A contains all emergency medicines required for treating chemical, biological, and nuclear warfare agents. The kit is provided with the following items.

- Three-colour detector papers for nerve and blister agents detection;
- Personal decontamination kits;
- Antidotes nerve agents - reusable autoject injectors and pyridostigmine bromide tablets
- Cyanide - amyl nitrite inhalant
- Radiation exposure - potassium iodate tablets;
- Medicines for treatment of sulphur mustard/phosgene/bacterial agents exposure and for pain, fever, and inflammation;
- NBC protective dressing for open wounds; and
- User handbook with a simple Standard Operating Procedure.

In addition to other features, the kit is ruggedized to withstand jerks and vibration during transportation and is also water-proof and drowning proof. FAK-A as per JSQR of FAK Mark II, has been submitted to Services for user trials.

First Aid Kit CW Type B Mark-II

Management of NBC casualties will be done in echelons. This comprises pre-treatment and first aid by soldier himself with the NAPS tablets and atropine autoinjectors, first aid and resuscitative measures at regimental aid post and decontamination followed by detailed medical treatment at advance dressing stations and forward treatment centres, etc. Existing medical equipment scale needs to be augmented with specific medical stores for management of CBRN casualties, especially in a chemical environment.

With the above objectives, the FAK CW-Type B is being subjected to revision as Mk-II version. This kit in conjunction with field-based FAK CBW Type-A kit, provides sufficient and state-of-the-art preparedness for NBC situations. The FAK-B Mk-II is under design review.



Autoject Injector

Autoject Injector is used to treat the NBC injured casualties, especially the nerve agent poisoning in the field by auto injecting the atropine sulphate and PAM chloride. Its importance is evident due to the fact that provision of self-injecting the atropine sulphate and PAM chloride is a must to survive against nerve agents poisoning. Many countries have developed



the Autoject Injector for atropine sulphate and PAM chloride, We have also developed, and bulk produced for the Services and the technology has been transferred to the Industry to achieve indigenization and self-reliance.



Technology of this product has already been transferred for bulk production and the product is inducted into the Services.

Activated Carbon Sphere

Activated Carbon Spheres have been prepared by stabilization, carbonization, and activation of resin beads at 800°C – 900°C in fluidized bed reactor. Activated carbon spheres are used as the critical adsorbents in permeable NBC suits. The size of the sphere is 250-710 micron and it can be stored normally at damp-free location at 25°C.



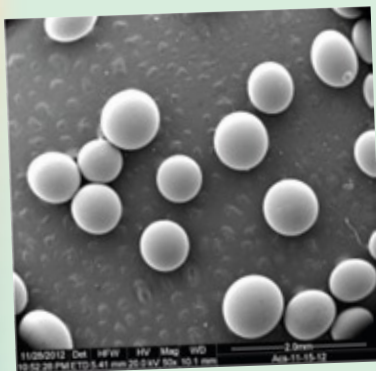
Technology of this product has already been transferred for bulk production and it is being used in NBC suits.

ACS Coated CBRN Suit (Mark-V)

DRDE has developed advanced version of CBRN suit for effective protection of personnel in NBC scenarios. The conventional NBC suit with powdered active carbon as the adsorbent has many drawbacks, viz., heat stress, low mechanical strength, wearing-off carbon adsorbent, low protection, etc. On the other hand, activated carbon sphere (ACS)-coated fabric has many advantages, viz., resistance to wear, tear and laundering, provides effective protection barrier, more air permeability/physical comfort and lightweight.

DRDE has developed indigenous technology at its pilot plant facility for the production of ACS required for the CBRN suit coating. CBRN permeable suit based on state-of-the-art technology of ACS beads sandwiched between the fabric layers having high adsorption capacity, leading to much

higher protection levels in comparison to NBC Permeable Suit MK-IV has been successfully developed. The salient features of developed CBRN Suit Mk V are: indigenous, excellent chemical agent protection, lightweight, high adsorbent ACS, oil and water repellency, fire retardant, physical comfort, launder ability, anti-static, high resistance and stability. The ACS process technology has been transferred to industry for bulk production.



Activated Carbon Spheres

Handed over to Army for users trial.



CBRN Suit (MARK-V)

ALKET : An Oral Antidote for Cyanide Poisoning

Cyanide is a highly toxic agent of both defence and civil interest. It is a potent suicidal, homicidal, and chemical warfare agent, and a preferred poison for terrorism act. It is widely used in the industries and poses occupational hazards. Hydrogen cyanide is a major component of fire smoke. Due to limitations of the existing cyanide antidotes, alpha-ketoglutarate (A-KG) is being developed as an effective oral treatment for cyanide poisoning. It is considered as a prophylactic agent during rescue operations of victims of smoke inhalation, occupational exposures, and therapy for suicidal, homicidal or accidental cases, and during out of hospital mass casualty scenario.



Phase-I clinical trial of ALKET is over. Regulatory approval as Investigational New Drug (IND) pending with DCGI.

AQUA Clean

Aqua clean is an efficient and instant pocket water purifier. It purifies the water instantly and provides microbe-free water from raw sources. Its an ideal choice for soldiers, travellers to get quality water.



NBC Filters

NBC filter is an important component of NBC ventilation/filtration system. NBC filter, a critical component of NBC ventilation/filtration system purifies the contaminated air by filtering out the NBC contaminants. It is a fact that accomplishment of breathable air through NBC filter is a must to survive. It's importance is evident due to the fact that many countries have developed NBC filters. NBC filter FAS 850M consisting of particulate (HEPA) and gas filter (NBC carbon) was developed, trial evaluated by Services, bulk produced for the Services and the

technology has been transferred to the industry. The indigenously developed NBC filter FAS 850M is on par to the filters of imported origin and very economical as it is five times less costly than the imported ones. It is the best example for self-reliance. An appreciable foreign exchange has been saved to the exchequer. As per the requirement of the Army, various models of these filters have been developed.



FAS 850M



FAS 400M



FAS 200M



FAS RV 200M



FAT 200M



FAT 100M



Technology of this product has already been transferred for bulk production and it is inducted into the Services.

Neelkanth Canister

This is an aluminium body canister, Neelkanth 'A' which can be used with any face mask for individual protection against NBC for supplying breathable air. It provides 2 h protection against persistent agents like blister and nerve agents. It has two main components: (i) High efficiency filter media (HEPA) to remove particulates of 0.3-micron size (nuclear dust, biological agents such as bacteria, viruses, and chemical aerosol), and (ii) impregnated activated carbon to remove toxic gases. It is bulk produced and inducted into the Services.

Neelkanth 'P' is a plastic body NBC canister and has been developed for providing 4 hr protection against blister and nerve agents as per specifications of the Army. It is also used to remove particulates (Nuclear dust, biological agents such as bacteria, viruses, and chemical aerosol) and chemical warfare agents (organic and inorganic) from contaminated air to make air breathable for personnel protection.

Technology has been transferred to private firms for bulk production.



Portable Decontamination Apparatus

Portable decontamination apparatus is a decontaminant dispersal device which facilitates the spreading of decontaminant over the contaminated surfaces. The spreaded decontaminant chemically degrades the chemical warfare agents and makes the surface clean for reuse. DRDE has developed the portable decontamination apparatus, trial evaluated by the Services, bulk produced for the Services, and the technology has been transferred to the industry. The indigenously developed apparatus is economical. It is one of the examples for self-reliance.



Technology has been transferred to private firms for bulk production.

Personal Decontamination Kit

It is used for the decontamination of CW agents by physical adsorption from human body, small areas on clothing, gloves, shoes, personal weapons, etc. This kit consists of three components (i) PDK-I (ii) PDK-II & (iii) RDP

Technology has been transferred to private firms for bulk production.

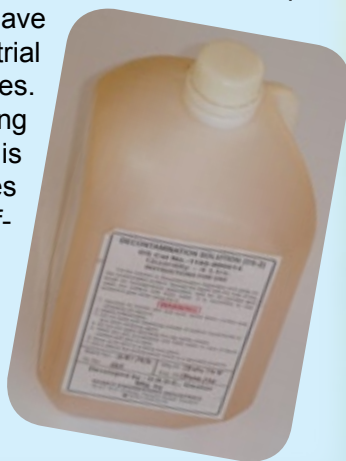


Decontamination Solution

Decontamination neutralizes the ill effects of CW agents and makes the equipment, buildings, area, vehicles, tanks, ships, small arms and ammunition reusable. Post CW warfare decontamination is therefore, very crucial. Decontamination for man and materials plays an important role for casualties evacuation, restoration phase, containment of contaminants, contamination due to desorption of adsorbed contaminants and also for survival. It's importance is evident as most of the countries have developed the personal decontaminants, decontamination kits, decontaminant dispersal devices and decontamination solution. These are very useful in the post-chemical warfare scenarios.

Decontamination solution (DS-2) reacts with chemical warfare agents to render these non toxic. It can be spread over the contaminated surfaces of vehicles, buildings, area, etc. using portable decontamination apparatus or through mobile decontamination systems. The spread decontaminant chemically degrades the chemical warfare agents and makes the surface clean for reuse. Its importance is evident due to the fact that many countries have developed "DS-2". DRDE have developed the DS-2 and trial evaluated by the Services. The decontaminating solution is economical. It is one of the best examples for marching towards self-reliance.

Technology has been transferred to private firms for bulk production and the product is inducted into the Services.



Chikungunya Diagnosis Kit

Chikungunya (CHIK) fever is an acute arthropod-borne viral illness reported from Africa, South-east Asia, Western Pacific, and India. The causative agent is CHIK virus (CHIKV), and it is primarily transmitted by Aedes mosquitoes. Enzyme-Based

Immunosorbent Assays (ELISAs) diagnostic tests hold a great promise for economical and convenient diagnosis of viral infections. DRDE has developed and evaluated a highly sensitive and specific kit based on IgM ELISA, Sandwich ELISA and RT LAMP Assay techniques for early detection of Chikungunya.



This kit is validated with more than 100 clinical samples (Serum and CSF), collected from Chikungunya outbreaks in different parts of India during 2006-2008. The kit is having 85 percent concordance, 96 percent sensitivity and 97 percent specificity with commercially available ELISA kits.

Technology has been transferred to private firms.

Dengue Detection Kit

Dengue is the most important mosquito-borne viral infection in mankind. It is widespread throughout tropical and sub-tropical regions of the world. Dengue is endemic in India and its outbreaks are reported at regular intervals from different parts of our country. All the four serotypes of dengue are reoccurring in India. There is no effective therapy or prophylaxis available against this disease. Therefore early diagnosis plays an important role in proper control and effective management of the diseases.

DRDE has developed and evaluated a highly sensitive and specific kit based on IgM ELISA and IgG ELISA techniques for early detection of Dengue. This kit is

validated with more than 100 serum samples collected from recent Dengue outbreaks in MP and AP (2006-2007). The kit is having 85 percent concordance, 89 percent sensitivity and 94 percent specificity with widely used commercial diagnostic kit (PanBio IgM capture ELISA). This kit has undergone multicentric evaluation and is now ready for technology transfer.



Japanese Encephalitis Detection Kit

Japanese Encephalitis (JE) is the most important viral encephalitis of public health significance. It is endemic throughout south-east Asia, including India. JE outbreaks are reported at regular interval from many parts of India. There is no effective therapy available against this disease. Therefore early diagnosis plays an important role in proper control and effective management of the disease.

DRDE has developed and evaluated a highly sensitive and specific kit based on IgM ELISA and Sandwich ELISA techniques for early detection of JE. This kit is validated with more than 120 clinical samples (Serum and CSF), collected from recent JE outbreaks in eastern UP (2005-2007). The kit is having 85 percent concordance, 93 percent sensitivity and 98 percent specificity with commercially available diagnostic kits. Technology has been transferred to private firms.



Glanders Spot Test

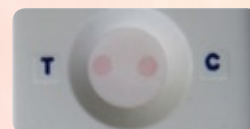
Glanders, caused by *Burkholderia mallei* is primarily a disease of horses, mules and donkeys, and can also

be transmitted to humans causing severe infection. *B mallei* is a listed bioterror agent. Equine glanders is a notifiable disease and recently many outbreaks have been reported from various parts of India. Glanders is presently diagnosed by complement fixation test and mallein hypersensitivity tests and both are laborious and time-consuming. This is first recombinant protein-based test system ever developed for diagnosis of glanders.

Recombinant BimA protein antigen is coated on the nitrocellulose membrane. Antibody present in serum/plasma binds to this antigen which is subsequently detected by detector solution. Appearance of brown coloured test spot is indicative of positive result. The rBimA protein has been evaluated with over 1500 equine serum samples in ELISA format and the results are encouraging.



Negative Test Result



Positive Test Result



Brucellosis Detection Kit

Brucellosis is a zoonotic infection usually transmitted to humans by contact with infected animals or by consumption of contaminated animal products. The ability of the bacteria to spread as aerosol makes them a potential biological warfare and biothreat agent. Several serological tests have been developed and are being used for the serodiagnosis of *Bovine brucellosis*. The most common of these is the agglutination-based tests mainly, Rose Bengal Plate Agglutination Test (RBPT) and Standard Tube Agglutination Test (STAT). The plate ELISA kit for the detection of *Bovine brucellosis* is developed as alternative to agglutination tests.

This product is ready for transfer of technology.

Positive

Negative



Typhigen Kit

Typhigen kit, developed by DRDE is used to detect Typhoid in blood samples. This kit can detect the bacteria within 02 minutes and it does not require specialized training. This kit is also cost-effective in comparison to other kits available in the market.



The technology has been transferred to private firms.

Laptosense Kit

DRDE has developed an effective kit for the detection of Laptospirosis bacteria. This kit is also based on IgM antibody DOT ELISA method. This kit requires only one drop of blood to detect the bacteria. Alternatively, plasma or serum can also be used for detection. It does not require any specialized training.

The technology has been transferred to private firms.



Plague Sense Kit

Yersenia pestis, which is responsible for Plague epidemic, is regarded as one of the deadliest biological agent. DRDE, Gwalior, has developed an effective kit for the detection of the deadly vector of this disease. This kit demonstrates the presence of HA and HA I antibody of *Yersenia pestis*. This kit is also cost-effective in comparison to other kits available in the market.



This kit is ready for technology transfer.

Anthrex Detection Kit – Anthr Ab

Bacillus anthracis, the causative agent of anthrax, is a large, gram-positive, non-motile, spore-forming rod shaped bacterium. Besides being one of the most important biological warfare agents, it causes public health problems also in both animals as well in human in countries with warm climate.



DRDE has developed a detection kit for anthrax, based on principle of Indirect ELISA. Patient's serum/plasma is added to the antigen pre-coated membrane. IgM/IgG specific antibody, if present in the sample, binds to the antigen. All unbound materials are washed away and the colloidal gold conjugate is added to bind to the Antibody-antigen complex, if present. Development of brown colour confirms the presence of IgM/IgG specific antibody in the sample. The intensity of colour developed depends



on the amount of antibodies present in the sample. It takes only 2 minute in detection. This kit is validated with more than 400 serum samples collected from anthrax endemic and non-endemic areas. The kit has 100 percent sensitivity and specificity with confirmed cases of anthrax.

Patent has already been filed for this product and the kit is ready for technology transfer.

Swine Flu Detection Kit

The recent emergence of swine origin influenza A H1N1 Virus (S-OIV) with high efficiency of human-to-human transmission raised a concern for global pandemic. The swine Flu pandemic in 2009 was caused by novel swine origin influenza A H1N1 Virus (S-OIV) that had not been recognized previously in pigs or humans.



DRDE has developed a one-step real-time reverse transcription loop mediated isothermal gene amplification (RTLAMP) assay for rapid and real-time detection of novel S-OIV RNA in clinical specimens by targeting the HA gene, requiring 30 min for confirmation. The S-OIV H1 gene-specific RTLAMP assay reported is simple, rapid, reliable, and inexpensive method as well as highly sensitive and specific.

RTLAMP technology for clinical diagnosis of swine flu patients is validated by evaluation with acute phase throat swab samples collected from the ongoing epidemic in India. Two patents have been filed in India.

The technology has been transferred to private firms.

Ricin Detection Kit

Ricin is one of the most toxic proteinaceous substances on earth that is extracted from the seeds of the castor plant commonly known as *Ricinus communis*. Ricin is a glycoprotein with molecular weight of 62 – 65 kDa, and consists of two chains A and B of nearly equal size linked together by a disulphide bond. It causes complete inhibition of cellular protein synthesis, leading to cell death.

Ricin has been considered as the biological warfare agent because of its high toxicity and easy availability. There is a need to have highly sensitive and fast detection method for ricin.

DRDE has developed a single-step ricin detection kit using the colloidal gold-conjugated antiricin antibodies. A positive test shows two visible bands at the control as well as test antibody-coated site, whereas negative test results in only one visible band at the control antibody-coated site. The test is completed in less than 5 -7 minute.

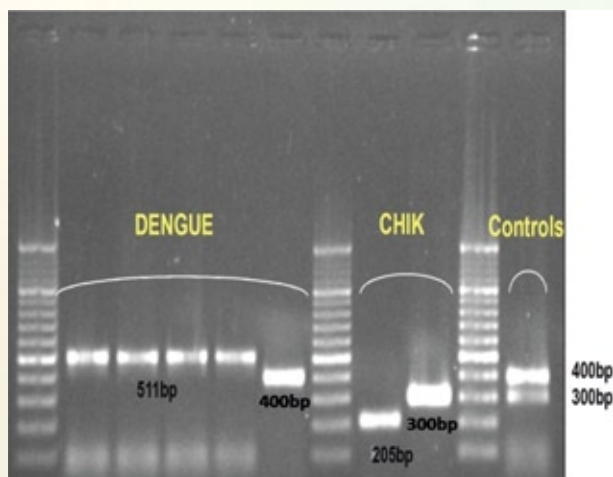
The technology has been transferred to private firms.



Den-Chik Duplex PCR

Dengue and Chikungunia have emerged as important viral infections all over the world. Early detection of these infections is necessary keeping in view their similar symptoms, affected geographical area and vector. DRDE has developed one-step, single-tube duplex reverse transcription polymerase chain-reaction (D-RT-PCR) assay for early detection of the infection. It can be used in an infection of just 01 day old. This assay can be used

to detect dengue and chikungunia infections in both human and mosquito.



CR-Based Grenades

DRDE, Gwalior has developed unique non-lethal munitions, named as CR-based grenades, which are totally safe, simple to operate, user-friendly, and extremely useful for the above purpose. The body of the grenades is made of plastic, which melts when the grenade bursts making its throwing back difficult.

The active component of CR-based grenade is CR (Dibenz-[b,f]-1,4-oxazepine), which is one of the peripheral sensory irritants, commonly used as a riot-control agent. CR can easily be dispersed as smoke (aerosol) from pyrotechnic mixture. Immediately after the exposure to the vapours or aerosol of the tear gas compound, there is an irritation and burning sensation (itching sensation) in the eyes, nose throat, mouth and all the exposed parts of the body. There is also tightness in the chest with difficulty in breathing. All the symptoms disappear within 15-45 minutes after the exposure requiring no treatment after exposure to CR. Individual, once exposed to CR should come



out and breathe fresh air. It is a very effective riot-control agent, which is far better than the commonly used agents for this purpose.

It has already been Inducted into the Services. These are being used for riot control by states' police and paramilitary forces also.

OR-Based Grenades

During a terrorist operation, one of the aims of the civil/military authorities is to catch hold of the terrorists alive to get more information about their ring leaders. Particularly when the terrorists take shelter in their hideouts or in house/building, it is very difficult to take them out without casualty to civilian as well as the terrorist. During the counter-insurgency operations, a security personal has to disarm/incapacitate an agitated individual, disperse a small crowd, or has to capture militants hold up in a bunker or building. The available methods in vogue are normally lethal in nature, e.g. small arms and grenades, which result in the loss of life/bodily injuries. There is a need for a non-lethal aerosol chemical-based weapon system, which is instantaneously effective and totally safe in controlling agitated and misguided individuals and can be used to incapacitate them.



DRDE has developed unique non-lethal munitions, named as oleoresin-based grenades, which are totally safe, simple to operate, user-friendly and extremely useful for the above purpose. The body of the grenades is made of plastic, which melts when the grenade bursts making its throwing back difficult. These can be thrown by hand up to 30 meter to the hideouts/agitated mob. The grenades when thrown emit tear gas for 60-80 seconds after a delay of 1-2 seconds, making the person to come out due to the lacrymation, irritation and suffocation.



It has already been inducted into the Services and, are also being used for the riot control agents by states' police and para-military forces.

CR-Based Shell

The CR-based shell can be thrown using a launcher up to 200 meter to the hideouts/agitated mob. The shells when thrown emits tear gas for 60-80 seconds after a delay of 5-7 seconds, making the person to come out from the hideout due to irritation, suffocation and lacrymation. Due to the above properties of CR, it can be used in combating terrorism by flashing out the terrorists alive from their hideouts. CR is a new, potent and less toxic sensory irritant compound. Exposure to CR produces unpleasant responses in human beings like tears, irritation, suffocation, nausea, etc. Effects wearoff within 30 to 45 min. There is no physiological damage to the human body. It is a more effective and safer compared to other known tear gas compounds. It has already been inducted into the Services.



Die-ethyl Phenyl Acetamide

Insects are carriers (vectors) of dreaded diseases such as malaria, dengue, chikungunya, etc. Various methods have been used for the ecological conditions with certain limitations. Application of insecticide residual spraying causes inconvenience to children and older persons that suffer from the toxicity. A better method would be to use a personal protection measure that is sufficient to protect human from the painful bites of blood-sucking organisms such as mosquito, sand fly, black fly, rat flea, and bed bugs. Die-ethyl Phenyl Acetamide (DEPA) spray and cream have been extensively evaluated in the laboratory and found to be effective over the commercially available repellents.

DEPA lotion and spray have been accepted and also recommended by the Director General Armed Forces Medical Services (DGAFMS). DEPA Spray is being regularly procured and used by Armed Forces.

It has been developed in the form of lotion, cream and spray. The technology of this product has been transferred to many private firms and the product is also commercially available in the market.



Slow-Release Insecticidal Paint

Slow-release Insecticidal Paint (SRIP) is basically developed to protect the wooden and metal products from insects such as cockroaches, badbugs, etc. This paint is suitable for use in ships, port and railways. This paint is safe for mammals and is very useful to kill and repel insects.



Efficacy of this paint is successfully tested in INS Vikrant. The technology has been transferred to private firms.

Attracticide

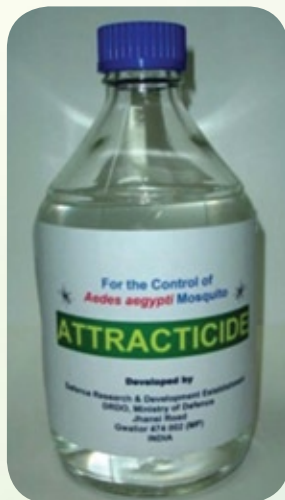
Aedes aegypti mosquito transmits dengue and chikungunya in India. It bites in day time and the eggs laid by the female *Aedes* mosquitoes can survive for a year without water at ambient temperature and humidity. The gravid female mosquitoes are in constant search of suitable water bodies to lay their eggs (oviposition). DRDE for the first time has reported the oviposition attractant pheromone (C21) of *Aedes aegypti* mosquitoes. This innovation was exploited to develop *Aedes aegypti* mosquito control technology. Thus "Attracticide formulation" having the property of "Lure and Kill", a combination of C21 pheromone with

insect growth regulator was developed.

This technology is very useful for monitoring and management of *Aedes aegypti* and *Aedes albopictus*, vectors of dengue and chikungunya, as a component of vector management program we besides being highly cost-effective and eco-friendly.

DRDE has developed an indigenous synthetic method for C21 and up-scaled it at DRDE's pilot plant facility to meet the requirements for the evaluation of Attracticide. Attracticide is non-toxic and Central Insecticide Board of India (CIB) has granted registration of attracticide under export category. Patents have been filed in India and foreign countries (US, Europe and Japan).

The technology for C21 synthetic process and Attracticide has been transferred to four industries for bulk production.



Wool Care

Carpets and woolen textiles including wool-synthetic blends are highly susceptible to insect damage by clothe moths and carpet beetles. Causing heavy losses to military, domestic, and commercial woolen stores in India. DRDE after a long search and extensive trials has developed a new moth-proofing agent that can be used both by industry as well as by households. The new moth-proofer for household use is also available in ready-to-use form as an aerosol spray to be used before storage.



The technology of this product has been transferred to the firms.

Biodigester Technology

Human waste is the by-product of food digestion and comprises feces and urine. It has foul smelling compounds and may contain pathogenic bacteria, viruses and parasites. Several diseases occur due to the contamination of drinking water or food by human waste. It needs to be treated before its discharge into the environment applying suitable technologies.

DRDE has developed anaerobic biodegradation method which has many inherent advantages: it does not essentially require energy for its operation and the amount of sludge generated is very less, main products are methane and carbon dioxide and inactivated pathogens present in the human waste. Based on this anaerobic biodegradation method, DRDE has developed the biodigester technology for human waste disposal for practical applications.



Biodigester is a specially designed fermentation tank with provision of inlet for human waste and outlets for treated effluent and biogas. Night soil degradation occurs through microbial reaction which converts it into biogas. The process results into treated effluent which is free from odour, suspended particle matter, pathogens and is environmentally acceptable. The technology includes specially designed fermentation tank and cold active microbial inoculum.

Spin-off of this technology developed for Indian Armed Forces has benefited civil sector in a big way. Thus, different types of biotoilet systems, viz., high altitude model, glacier model, railway model, plain area model, island model, biotank model, as per the requirement, have been developed and put in use successfully.

This technology has been transferred to many private firms.



Railway Biodigester

After the huge success of Stationary Biodigester, DRDE has developed the technology for disposal of human waste generated onboard railway coaches.

The Rail biodigester is made of stainless steel and is of rectangle shape for underslung operation. The digester has two basic chambers, one for biological and the other for the chemical treatment. The combination of these two treatments results in odourless effluent for safe discharge. The digester contains PVC-based immobilization matrix on the partition and side walls for entrapping the bacteria to cope with sudden washouts by accidental pouring of large amount of water in the toilet. It also takes care of the occasional adverse conditions created

by the accidental use of chemicals like detergents and antiseptics. Further, it also enhances the rate of biodegradation by retaining higher bacterial mass.

DRDE developed biodigesters are going in a big way in Indian Railways. Currently, more than 4000 biodigesters are functional in various trains running in different geo-climatic regions of the country. Four hundred new coaches fitted with biodigesters have been rolled out this year. 10000 more biodigesters are to be installed by end of current financial year. Retrofitment of biodigesters in already running coaches (>50,000) will be completed before 2017. Slowly and steadily, all the trains will be fitted with eco-friendly biodigester to alleviate the pollution in Indian railways, the biggest public carrier in the world.



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