

# UNIVERSITY OF NEW HAMPSHIRE

Advanced Polymer Laboratory Thompson Hall 107 Tel: (603) 1948-1948 Fax: (603) 862-3617

Email: ygd@cisunix.unh.edu

White Paper: Delivery of chemicals by microcapsules.

Prepared by Dr. Yvon G. Durant

ABSTRACT: Non-lethal crowd control is a central issue facing field units in police-type situations in which they increasingly are deployed. This proposal offers significantly improved ways of delivering chemical agents similar to ones already being used, but crudely delivered, such as tear gas, as alternatives to blunt trauma-type munitions such as rubber bullets. It also makes feasible the use of marker dyes to identify participants. The characteristics of polymeric microcapsules can be used to project a liquid much further, control dispersion in ways not now possible, and prevent redirection by opponents.

The University of New Hampshire (UNH) is pleased to submit this White Paper to the U.S. Marine Corps' in response to request for new non-lethal technology ideas. This White Paper specifically addresses delivery of chemicals by microcapsules. The selection of chemicals can be made by potential users, though early candidates would be crowd-dispersal agents, and chemical markers and tracers like dyes.

It is anticipated that these new technologies are projectable beyond 100 meters, and are well suited to increasing crowd-control capability without in any way sacrificing existing offensive and defensive capabilities and options. They could be used to incapacitate personnel, to clear facilities and / or areas of personnel, and to maintain control of areas after active hostilities cease. The most foreseeable use involves the frequently predictable but extraordinarily difficult situation in which unfriendly mobs of civilians are being used by an opponent in an urban setting to achieve ends unattainable through military means.

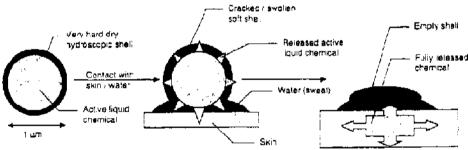
Deliverable: Proof of concept, synthesis of microcapsules in small (10g) quantities.

Overview: We propose to deliver at short and long ranges liquid chemicals through a two-stage delivery system. Active liquid chemicals are embedded into hard polymene hydroscopic microcapsules. An existing delivery vehicle (see further) releases the payload of chemicals causing blunt trauma. The microcapsules have a shell that decomposes when in contact with skin and water (such as sweat) and releases chemical.

## Description:

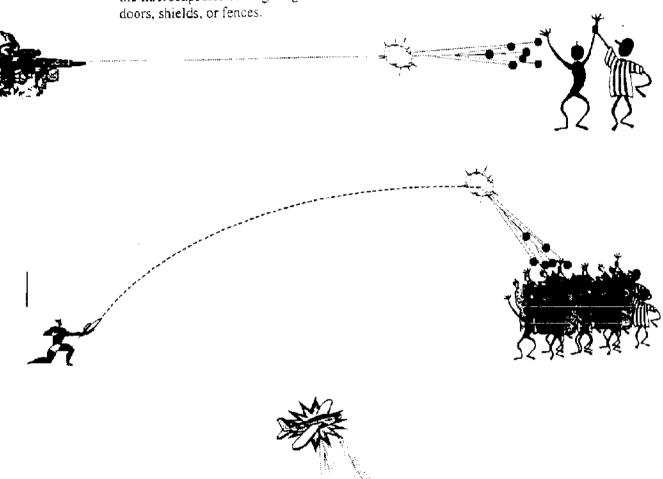
Principle: Three components are essential for this new concept.

Microcapsules are structured spherical particles, a few micrometers in diameter, containing for the most part liquid organic chemical. Macroscopically they look like extremely fine powders. Because of their small size they offer extremely large contact areas, and consequently very fast release action times. The core of the capsule contains the active liquid chemical of choice (see next section). The shell is the key material. It can be made of a crosslinked copolymer, and is very hard under dry condition but very hydroscopic. Consequently the capsule keeps its integrity during storage and delivery, but "dissolves" upon contact with moisture present in and on the skin.



- 2. Chemicals: Standard drugs used in medicine for anosthesia are desirable candidates, since their acceptance in the general public would not be an issue. As a mild deterrent force simple colorants could also be used to tag the aggressor. At the other end of the force spectrum a combination of corrosive / anesthetic chemicals, embedded in separated capsules can be used to offer penetration through protective gears without blunt-trauma.
- 3. Delivery vehicle: Several existing delivery systems are good candidates for this payload. Each of them achieve the goal of bringing the payload within a few meters of the target.
  - A shotgan. The microcapsules are loaded in the cartridge. Upon firing the powdery load of microcapsules impact weakly with the target. This is convenient only at close range, because of the lack of accuracy of a shotgun and significant air drag of microcapsules.
  - A mortar explosive shell. A ballistic shot of a mortar shell is executed above the target area, the shell explodes in mid-air, the payload is sprayed over the targets.
  - An Unmanned Aerial Vehicle (UAV) can release the payload over the target area.

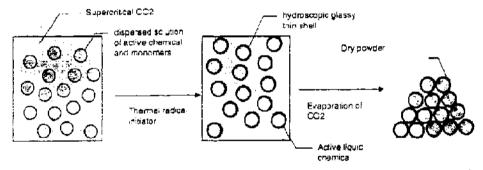
• The recently proposed replacement of the M16 assault rifle, the Objective Individual Combat Weapon (OICW). [Alliant TechSystems of Hopkins, Minnesota <a href="http://www.atk.com/releases/1995/04apr.l/oicwformat.htm">http://www.atk.com/releases/1995/04apr.l/oicwformat.htm</a>], will have a 20mm high-explosive (HE) air-bursting ammunition, with range and fuse delay control. Substituting 90% of the explosive with the microcapsules, a soldier could deliver the microcapsules at long ranges in hard to reach areas, such as behind windows, doors shields or fences.





### Technical justifications and background:

- 1. To avoid blunt trauma, it is necessary to reduce the weight of the projectile or dramatically increase the ratio of the contact area to projectile weight. Microcapsules fulfill these requirements. The down side being the slow kinetic due to high air friction.
- 2. Active liquid chemicals have two major advantages: they do not create irreversible surface wounds, and they can penetrate fairly fast through the skin to achieve rapid disruptive function. Comparatively, gases can act faster, but cannot be propelled accurately, nor is it easy to control their exposure.
- 3. Microcapsules can carry active chemicals in a safe manner. They can be filled with several types of chemicals, such as "mace", anesthetic or paralytic agents. Microcapsules of several types can be mixed in a safe and non-reactive manner until release. Alternatively a combination of two reactive liquid chemicals can generate a gas at the point of delivery. Various types of non-lethal weapons can be generated on the basis of this new-technology.
- 4. The fairly recent polymerization process named 'mini-emulsion" offers a very wide



range of possibilities to build microcapsule structures. This process is conventionally used in water, but some recent research efforts in supercritical CO<sub>2</sub> have shown that it can also be carried out in non aqueous environments. Furthermore supercritical CO<sub>2</sub> offers the advantage of producing dry powder without difficulties. Mini emulsion allows the dispersion in CO<sub>2</sub> of a solution of organic molecules (active chemical, and monomers) through the use of a mechanical source of energy such as ultrasounds. After dispersion a conventional thermal initiator polymerizes the monomer to form a polymeric capsule around the active chemical. In the last step the microcapsules are dried by evaporation of the CO<sub>2</sub> phase. The copolymer composition (polyacrylic acid, polyacrylamid, polystyrene sulfonate), controls the polarity, the compatibility with the chemical(s) to be delivered, and the mechanical properties of the shell.

- 5. The University of New Hampshire as been a leader in the development of controlled morphologies for polymer coatings. UNH has extensive experience in chemical microencapsulation, and in mini-emulsion.
- 6. On the other hand UNH has no special knowledge of paralytic, anesthetics, and "mace" chemicals. A partner must be found in this area.

#### Essential steps of the "proof of concept" study:

- 1. Identification of a suitable chemical or chemicals. Identification of a partner / consultant.
- 2. Evaluation of the pressure stress on the capsules due to the release. Kinetic / ballistic study of microcapsules.
- 3. Identification of the polymer constituting the hydroscopic shell.
- 4. Identification of a process to synthesize the microcapsules.
- 5. Synthesis of microcapsules loaded with inert color agents.
- 6 Mechanical tests with dynamic mechanical analysis, chemical release tests.
- 7. Synthesis of microcapsules loaded with active chemical.
- 8. Delivery trials (simulated UAV drops) of microcapsules loaded with mert color agents.

Risks: The technologies described above have emerged relatively recently, and have not been used for the proposed purposes. In addition, the whole concept of using hard hydroscopic microcapsules for delivery of liquid substances for crowd-control or identification is novel. Development may entail unknown technical issues. The selection of chemical payload is sought from the user, and will require substantial sensitivity given the potential applications of this technology.

Time requirements and focus: The proof of concept study is projected to require a year and a half to complete. While downstream issues like identification of chemicals and delivery systems need to be addressed, efforts will focus primarily on the synthesis of suitable hydroscopic polymeric microcapsules in small (10g) quantities.

### University of New Hampshire - White Paper Cost Estimate

BAA-98-R-0016

Title: Delivery of Chemicals by Microcapsules

Project Director: Dr. Durant

18 Month Project

Personnel and Fringe Benefits \$125,500

Material and Other Expenses \$272,000

Facilities and Administrative Costs \$89,000

Total \$486,500