

Brochosomes: An Enigma of Leafhoppers

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Brochosomes are unique ultramicroscopic particles produced by leafhoppers (Hemiptera: Cicadellidae). These protein–lipid granules are synthesized in the Malpighian tubules and released through the hindgut as a colloidal suspension, after which insects spread them over their body surface or egg masses using specialized leg movements. Brochosomes exhibit a characteristic hollow, honeycomb-like structure and show remarkable functional properties such as water repellence, anti-reflective surfaces, and protection against environmental stress and natural enemies. The diversity of their structure and the behaviors associated with their application make them an intriguing biological adaptation. Recent biomimetic research has also inspired the development of synthetic brochosomes for technological applications in materials science and nanotechnology.

Keywords: Brochosomes, Leafhoppers, Superhydrophobicity, Egg protection, Biomimetic materials

Introduction

Leafhoppers (family Cicadellidae) are small sap-feeding insects widely distributed in agricultural and natural ecosystems and include many economically important pest species. One of their most remarkable biological features is the production of brochosomes, microscopic particles that coat the insect body or egg masses. These particles were first observed using an electron microscope in 1952 and are recognized by their reticulated surface that resembles a honeycomb pattern. Brochosomes are synthesized in the Malpighian tubules and secreted shortly after molting. Leafhoppers actively distribute these particles over their integument through grooming and anointing behaviors. The unusual structure, composition, and diverse biological roles of brochosomes have attracted considerable interest in both entomology and biomaterials research.

Composition and types of brochosomes

Composition

- Brochosomes are ultramicroscopic **protein–lipid granules** usually measuring **0.2–0.6 μm in diameter**.
- Their structural skeleton mainly consists of **glycine-rich proteins** known as **brochosomins**.
- Several brochosomin proteins have been identified, including **BSM-1, BSM-2, BSM-3, and BSM-4**, encoded by specific **BSM genes**.
- These particles possess a **hollow internal cavity** and a **reticulated outer wall** forming a mesh-like structure.
- The unique architecture contributes to their physical and biological properties.



Figure 1

Soon after moult, leafhopper adults and in some lineages, nymphs release colloidal suspension of brochosomes through the hindgut and apply it with their legs onto the fresh integument.

Types of brochosomes

1 Integumental Brochosomes (IBS)

- Typically spherical in shape.
- Applied on the insect's body surface after molting.
- Often resemble a **truncated dodecahedron** with hexagonal and pentagonal faces.

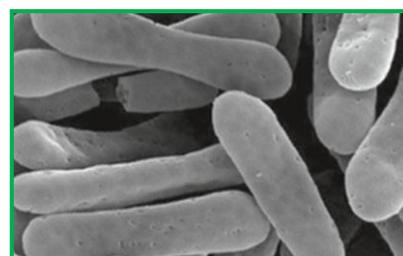
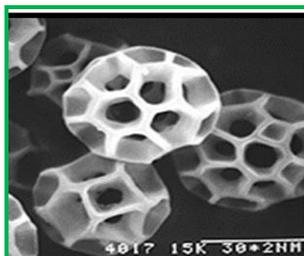


Figure 2. Integumental Brochosomes and Egg Brochosomes

2 Egg Brochosomes (EBS)

- Usually **rod-shaped or elongated particles**.
- Produced only by females of certain leafhopper genera.
- Deposited on egg masses during oviposition to form a protective covering.

Structural diversity of brochosomes

- Brochosomes exhibit remarkable **variation in size, shape, and surface pattern** among different leafhopper species.
- Integumental brochosomes often display a **truncated dodecahedral geometry** composed of hexagonal and pentagonal faces, similar to the structure of a soccer ball.
- The outer surface contains **numerous pits and ridges** that form a honeycomb-like architecture.
- These microscopic pits and cavities contribute to the **optical and hydrophobic properties** of brochosomes.
- Structural diversity is believed to be associated with **species-specific adaptations and ecological functions**.

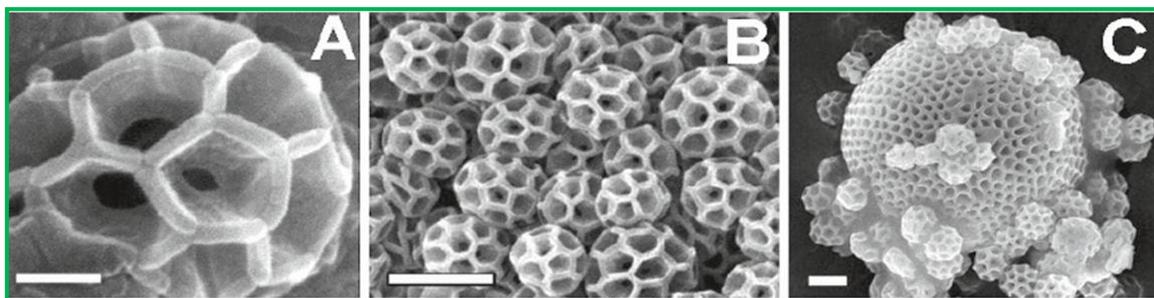


Figure 3. Structural diversity of brochosomes

Related behaviours associated with brochosomes

Leafhoppers exhibit specialized behaviors to distribute brochosomes effectively over their body surface.

- After molting, a **colloidal suspension of brochosomes** is released through the hindgut.
- The insect captures the secretion with its **hind legs** and spreads it over the integument.
- This process is known as **anointing**, during which brochosomes are evenly applied to the body and wings.
- Leafhoppers perform **grooming movements** to distribute the particles uniformly.
- **Rows of specialized spines on the legs** function as tools for manipulating brochosomes.
- Grooming may also help **repair damaged coatings** by redistributing particles.

Properties of Brochosomes

Brochosomes possess several unique physical and biological properties.

- 1) **Superhydrophobicity:** Brochosome coatings make the insect surface highly water-repellent, preventing wetting.

- 2) **Anti-reflective property:** Their micro- and nanostructure reduces light reflection, which helps in camouflage.
- 3) **Ultraviolet protection:** The structural arrangement and chemical composition can absorb or reduce UV radiation.
- 4) **Resistance to adhesion:** Brochosomes prevent sticky substances such as plant exudates from adhering to the insect body.
- 5) **Optical effects:** The pits and ridges cause **diffraction and scattering of light**, contributing to reduced reflectance.

Functions of Brochosomes

Brochosomes serve several protective and ecological roles in leafhoppers.

- ✓ **Prevention of egg desiccation** by forming a protective coating around egg masses.
- ✓ **Protection from ultraviolet radiation**, reducing harmful effects of sunlight.
- ✓ **Defense against parasitoids**, which may find it more difficult to locate or attack eggs covered with brochosomes.
- ✓ **Protection against predators** by enhancing camouflage through reduced reflectance.
- ✓ **Antimicrobial protection** for eggs and the insect integument.
- ✓ **Signaling function**, indicating that a leaf already contains eggs and preventing additional oviposition by other females.

Synthetic Brochosomes and Their Applications

- **Synthetic brochosomes** are artificial particles developed to imitate the **structure and functional properties of natural brochosomes** produced by leafhoppers.
- These particles are usually **micro- or nanoparticles with porous or reticulated surfaces**, similar to the honeycomb-like architecture of integumental brochosomes.
- Their unique structure provides **remarkable liquid-repellent and anti-reflective properties**, making them useful for technological applications.

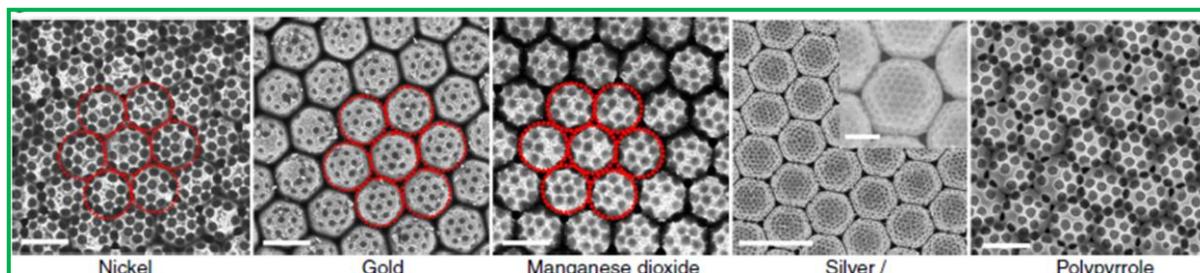


Figure 4. Synthetic brochosomes

- Synthetic brochosomes are being explored for **water-repellent coatings and superhydrophobic surfaces**.
- They are also useful as **antireflective coatings in optical materials and solar devices**.
- In addition, they have potential applications in **photocatalysis, structural colour materials, and nanoplasmonic technologies**.

These biomimetic particles demonstrate how **natural insect structures can inspire advanced materials in nanotechnology and surface engineering**.

Conclusion

Brochosomes represent a remarkable biological innovation in leafhoppers, characterized by their unique structure, composition, and multifunctional roles in protection and survival. Their diverse properties, such as water repellence, anti-reflective ability, and defense against environmental stress, highlight their ecological significance. Furthermore, the study of brochosomes has inspired the development of synthetic analogues, demonstrating their potential applications in biomimetic materials and advanced nanotechnology.

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