doi:10.1038/nindia.2012.100; Published online 13 July 2012

Science news

Cocoon formula for green buildings

K. S. Jayaraman

Houses that don't need air conditioning could be designed by mimicking the structure of the cocoon that silkworms use to keep their pupae[1].

The technology used by these insects can also help design protective capsules for humans exploring the cold arctic, hot deserts or the vacuum of space, they say.

The cocoon is an architectural marvel, says Sadyasachi Sarkar (inset).

Sabyasachi Sarkar, senior professor of chemistry at the Indian Institute of Technology Kanpur (IITK) and co-workers reached this conclusion after studying the structure of the cocoon. They report that the cocoon is an 'architectural marvel' and understanding its structure could be helpful in developing energy saving structures and gas filters.

"The cocoon is designed to house the pupa till it is transformed to a full grown adult moth that may last from few weeks to as long as 9 months," Sarkar told *Nature India*. To do so, the cocoon membrane should be able to flush out carbon-dioxide from the confined chamber and allow uninterrupted inflow of fresh air. Additionally, the temperature inside the cocoon should be controlled for the pupa to survive.

How is the cocoon able to do all this?

Sarkar and co-workers set out to resolve this puzzle by analysing the structure of as many as a dozen cocoons of the semi-domesticated Tasar silkworm (*Antherea mylitta Drury*) of Chattisgarh using X-ray, electron microscopy and other tools.

They found that the cocoon membrane is asymmetric and acts as a 'gas filter' allowing it to preferentially pass CO_2 from inside to outside but not the other way round. It also regulates the temperature inside the cocoon irrespective of the outside temperature.

"To the best of our knowledge, this is the first evidence showing the unidirectional flow of CO_2, or gating, across the cocoon membrane," the scientists report.

The researchers simulated CO_2-rich external environment and noticed that the CO_2 did not diffuse into the cocoon. But when CO_2 was injected inside the cocoon it diffused out in 20 seconds indicating that the cocoon's structure did not allow the build-up of CO_2 inside.

In contrast, the scientists found that the membrane promoted bidirectional flow of oxygen (O_2) essential for the pupae to survive. Further, they showed that the temperature inside the cocoon remained between 25 and 34 degrees C even when the external temperature was varied from 5 and 50 degrees C indicating "the membrane has an intrinsic temperature controlling system."

Silk fibre is made up of the structural protein called 'fibroin' bonded into a non-woven matrix with another glue-like protein called 'sericin'. This structural strategy must have evolved for a protective function to safeguard the development of the pupa within the cocoons which have additional composite materials to augment the protection, Sarkar said.

The scientists have an explanation for why the membrane prevents CO_2 from entering into the cocoon. They say the 'calcium oxalate hydrate' crystals which are naturally present on the outer surface of the cocoon block the flow of the gas from outside to inside by trapping most of the CO_2 as hydrogen bonded bicarbonate on the surface. The intrinsic weaving pattern of silk also contributes to the gating of CO_2, the scientists said.

The researchers conclude that CO_2 'gating' and thermoregulation helps in maintaining an ambient atmosphere inside the cocoon for the growth of pupa. "We could mimic such regulatory membrane using modern nano-structural materials. Then it could be used as a gas filter and for developing green energy saving housing material," Sarkar said.

"The material could be used in exploration under desert or cold conditions, or for space exploration, and designing incubators for hospitals. Green buildings with lower costs for heating/air-conditioning are also a possibility", Sarkar added.

References

1. Roy, M. *et al*. Carbondioxide Gating in Silk Cocoon. *Biointerphases*. 7, 45 (2012) | **Article** | **PubMed** |

Nature India EISSN 1755-3180 Header image source: Getty