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Combination of Low Viscosity Polydimethylsiloxane and Very Low Amounts of Repellent Ingredients Enables Effective Repellency

Toward No Fear of Mosquito Bites and its Diseases
through an Easy and Comfortable Repellent for Daily Mosquito Care

The Personal Health Care Research Laboratory of Kao Corporation has found that a combination of low viscosity Polydimethylsiloxane (L-PDMS) with very low amounts of repellents*¹ such as Citronella oil or DEET can greatly increase the mosquito repellent effect. Direct transfer of repellents could be determined as major driving force for these observations. This interplay allows very low concentrations of repellents to be highly effective for the prevention of mosquito bites.

These findings were reported at the 44th annual meeting of the Association for Chemoreception*² Sciences, held in Bonita Springs, Florida, USA on April 29, 2022.

*1 Regulation of repellent active ingredients is different in each country

*2 Biological sense derived from chemical stimulation such as taste or odor sense.

■ Background

Mosquito-borne diseases are posing an increasing threat to a wide range of people worldwide. Despite great efforts to control outbreaks, Malaria and Dengue fever see reoccurring waves of infection. Personal protection using mosquito repellents is a main defense for many affected people. The most potent mosquito repellents available to consumers use high percentages of repellent ingredients which is often accompanied by an unpleasant skin feeling and odor. Creating better protection against mosquito bites through easy and pleasant to use products is required around the globe. Research of new repellents can contribute to broader acceptability and higher usage rates of mosquito repellent products, leading to a decreased risk of mosquito-borne infections. Following this, we previously reported the identification of a new repellence mechanism utilizing hydrophobic liquids to induce an escape response of mosquitoes after tarsal contact*³. Low viscosity Polydimethylsiloxane (L-PDMS), a commonly used ingredient for

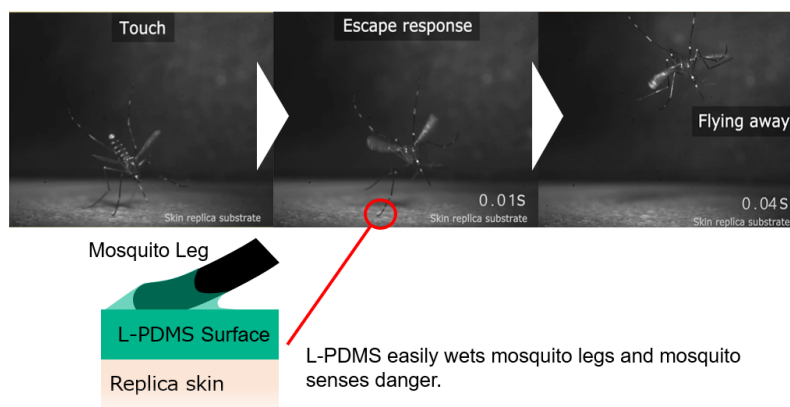


Fig. 1: Mosquito avoids landing on L-PDMS

cosmetics, is avoided by mosquitoes and considered not suitable for landing. If the mosquito lands on such a skin, L-PDMS can easily wet the mosquito leg and it senses danger. Rapid wetting of the leg induces a certain gravity and triggers an escape response in the mosquito. It directly leaves the surface (Fig.1). This unique mechanism of L-PDMS can solve current issues with mosquito repellents such as unpleasant usage feeling & odor and can be a breakthrough for the development of new mosquito repellents which contribute to the protection of people against mosquito-borne diseases. Deepening the knowledge and exploring the potential of this repellence mechanism, combinations with commonly used repellents, such as Citronella oil and DEET were explored. Surprisingly, combining L-PDMS with very low amounts of Citronella oil or DEET results in a remarkable boost of the repellence effect. To achieve a similar potency these two repellents need to be used at much higher concentrations in current commercial mosquito repellents.

*3 KAO News release on December 9, 2020; [Kao | Technology for Preventing Mosquito Bites Developed by Creating a Skin Surface Mosquitoes Dislike —Protecting Against Mosquito-borne Infectious Disease—](https://www.kao.com/technology/creating-a-skin-surface-mosquitoes-dislike-protecting-against-mosquito-borne-infectious-disease)

Iikura, H., Takizawa, H., Ozawa, S., Nakagawa, T., Matsui, Y., Nambu, H. Mosquito repellence induced by tarsal contact with hydrophobic liquids. *Sci. Rep.* 10, 14480 (2020). <https://doi.org/10.1038/s41598-020-71406-y>

■ Examination of the repellent efficacy in combinations of L-PDMS and repellent ingredients

Arm-in-cage Experiments (AIC) can determine the potency of repellent materials by exposing a part of the arm of a volunteer to mosquitoes and observe their behavior. Studying 25 mosquitoes at a time we observed the biting behavior, when the skin was treated with a sample contained trace amount of Citronella oil ($4 \mu\text{g}/\text{cm}^2$ on skin) at a dosage 10~100 times lower than commercial citronella repellents. At this concentration it reveals very low potency to repel mosquitoes. Remarkably, combining low concentrated Citronella oil with L-PDMS ($0.2 \text{ mg}/\text{cm}^2$ on skin), the mosquito repellency was greatly increased, leading to a reduction in mosquito landings (Fig. 2 left). Noteworthy, this effect is also observed when using $0.2 \mu\text{g}/\text{cm}^2$ DEET on skin, a concentration where DEET is almost completely inactive when used alone (Fig. 2 right).

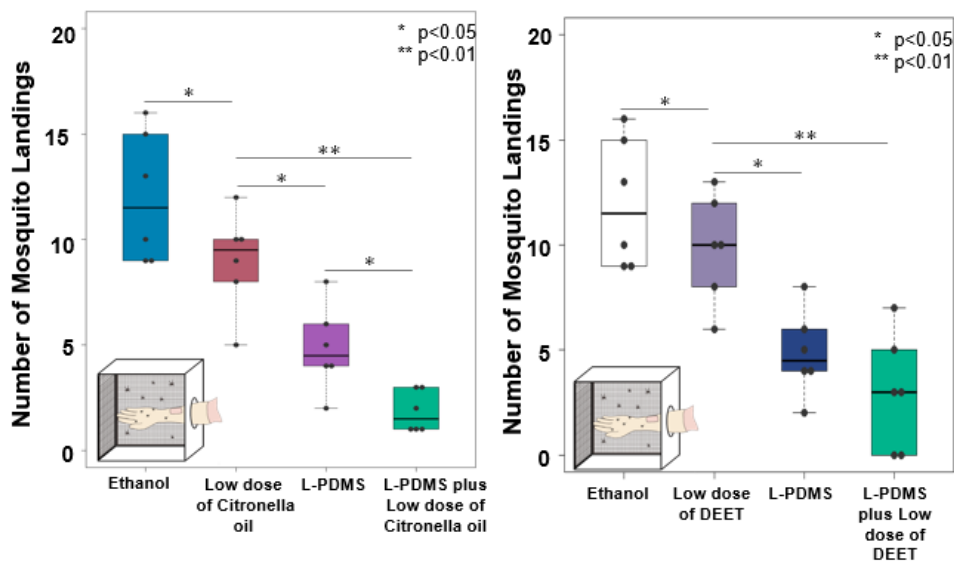


Fig. 2

Left: L-PDMS and low dose of Citronella oil enhance repellency;

Right: L-PDMS and low dose of DEET enhance repellency;

■ Exploring the mechanism behind the effect of combinations between L-PDMS and repellent ingredients

These surprising results lead to further studies aiming at deeper insight into the mechanism behind this observation. L-PDMS can efficiently transfer to mosquito legs as seen in previous studies, following this trail we investigated whether this would influence the transfer of Citronella oil. Touching a surface coated in L-PDMS and Citronella oil with separated mosquito legs, we found a considerable increase of Citronella oil on the mosquito leg, compared to the control. This effect was unique to L-PDMS and other liquids such as Glycerol could not show this effect. Main driving force is the transfer of L-PDMS to the mosquito leg upon landing, which mediates delivery of Citronella oil (Fig. 3). Mosquitoes are able to taste such ingredients by sensory receptors located on their legs. Through the efficient and direct delivery of Citronella oil/DEET to their legs, mosquitoes can even detect very low concentrations. This leads to a better protection against mosquito bites.

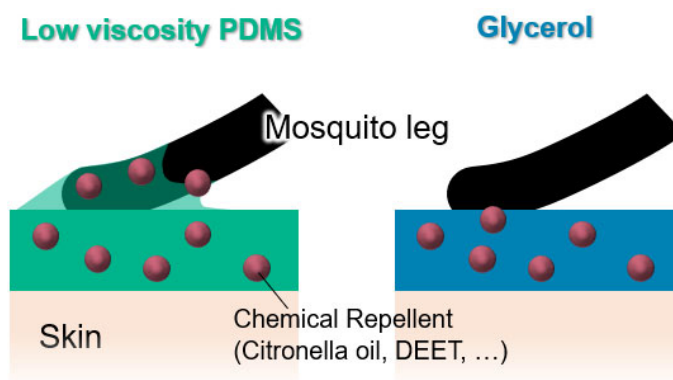


Fig. 3: Repellent is delivered to mosquito leg by L-PDMS

■ Conclusion

Increasing the efficiency of low concentrations of repellents like Citronella oil or DEET through L-PDMS can provide a pathway for better mosquito care. Using L-PDMS, a widely used cosmetic ingredient, can provide a significantly improved skin feeling compared to classical mosquito repellents. Combining this technology with low concentrations of Citronella oil, can reduce the unpleasant odor. Kao will continue to develop technologies for easy&comfortable mosquito care and aim to contribute to the reduction of the number of mosquito bites as well as the prevention of mosquito borne infectious diseases.

About Kao

Kao creates high-value-added products that enrich the lives of consumers around the world. Through its portfolio of over 20 leading brands such as *Attack*, *Bioré*, *Goldwell*, *Jergens*, *John Frieda*, *Kanebo*, *Laurier*, *Merries*, and *Molton Brown*, Kao is part of the everyday lives of people in Asia, Oceania, North America, and Europe. Combined with its chemical division, which contributes to a wide range of industries, Kao generates about 1,420 billion yen in annual sales. Kao employs about 33,500 people worldwide and has 135 years of history in innovation. Please visit the Kao Group website for updated information.

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