English

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Process Development for Producing Renewable Aviation Fuel

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【106 Ta-You Wu Memorial Award】Special Issue

"Green Air" is now a popular task for developing an energy-sustainable and environmental friendly aviation. Drop-in alternative aviation fuel from renewable source, which reduces both the fuel consumption and engine pollutants, has been viewed as the best choice. Our research team has developed a JP-5-like aviation fuel based on the requirements of jet engine combustion and reducing emissions and in accordance with the most appropriate process and feedstock locally in Taiwan. The produced fuel, as shown in Fig. 1, has relatively lower sulfur content and higher C-H ratio compared to traditional jet fuel, is expected to reduce the PM emission from aircraft engine. The future study will be focused on the influences of fuel components and characteristics on the characteristics of flame, spray quality and ignition, which directly/indirectly associate with the emission of NO_x，CO，HC from the jet engine. In addition, the experimental conditions and results were applied to the process simulation, which the resulting mass and energy balances were used to perform the techno-economic analysis, for the purpose of evaluating the large scale production cost for producing renewable aviation fuel.

Fig. 1 "Home-made" renewable aviation fuel

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Data Envelopment Analysis for Marginal Profit Maximization

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Lee, Chia-Yen, 2014. Meta-Data Envelopment Analysis: Finding a Direction Towards Marginal Profit Maximization. European Journal of Operational Research, 237 (1), 207–216.

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This study describes the production behavior. In data envelopment analysis (DEA), the input-oriented efficiency measure and output-oriented efficiency are two typical ways for technical efficiency estimation. However, it is difficult to reduce input with maintaining the same output level or increase output level without increasing input. The two orientations are argued in practice. This study suggests that the firm should move toward the marginal-profit-maximized benchmark.

This study uses mathematical programming technique to estimate the production frontier, and build the meta-DEA frontier (i.e. frontier about frontier) by the directional marginal productivity. Given the price information of inputs and outputs, the marginal-profit-maximized benchmark can be identified. That is, the allocatively-efficient target on the meta-frontier, as following Figure 1. Typical DEA frontier is based on the "level" while the meta-DEA frontier is based on the "margin". Thus, we can estimate the technical efficiency via the marginal-profit-maximized orientation, and give a comparison to the input-oriented measure and output-oriented measure for clarifying the managerial insight.

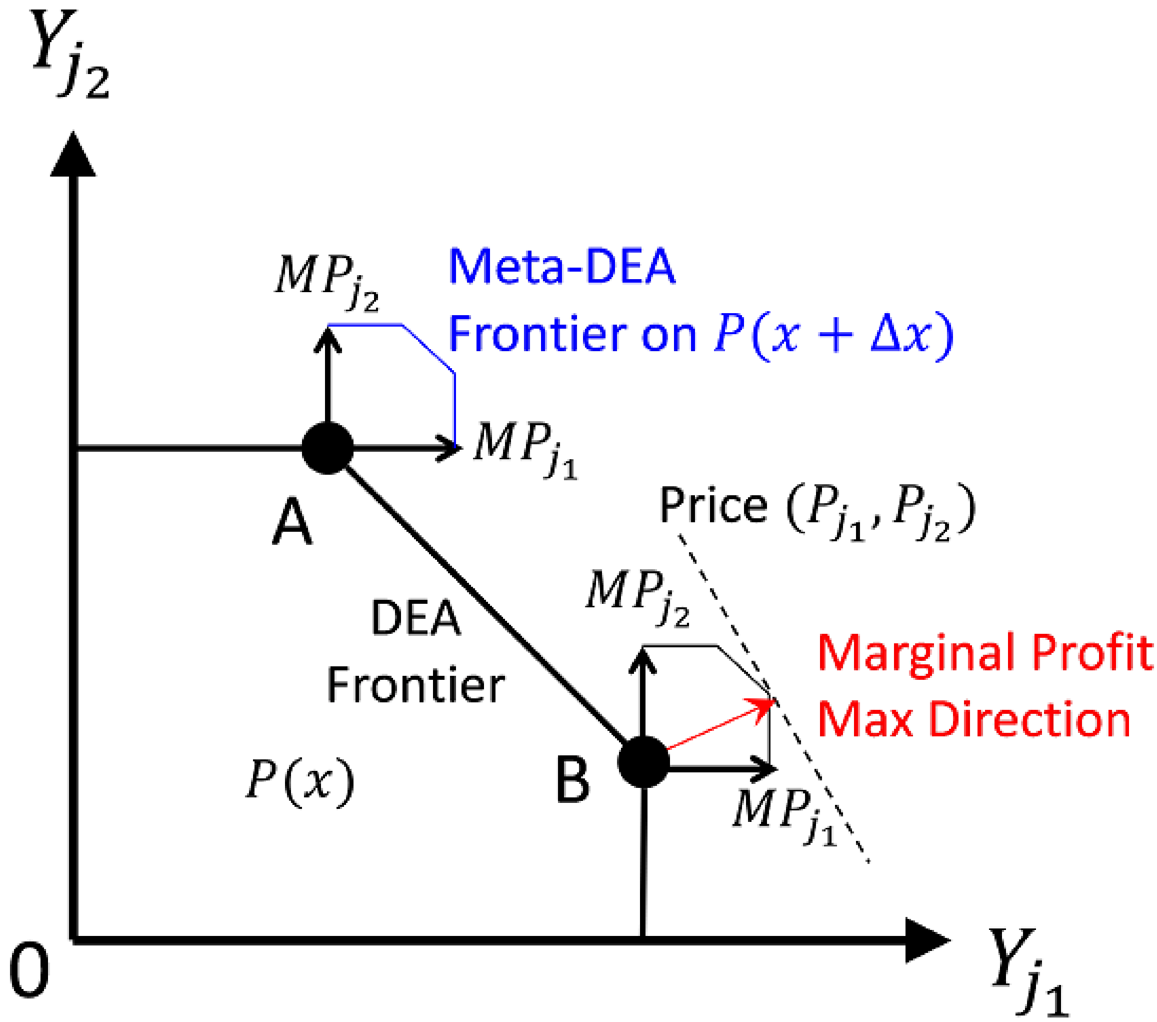

Figure 1 Efficiency estimation by marginal-profit-maximized benchmark

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Boltzmann equation: old and new

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一、Introduction

The Boltzmann equation is one of the most fundamental equation of the kinetic theory, the unknown function f(t,x,v), which stands for the mass density function of gas particles having position x, velocity v, and time t . It satisfies a differential equation:

$$\frac{df}{dt} + v \cdot \nabla_x f = Q(f,f).$$

The left hand side of the equation represents the particle transport with the velocity v, and the right hand side of the equation represents the interaction between two colliding particles, it includes hard sphere case, hard potential case and soft potential case. However, if we consider inverse power force between particles, there will be some angular singularity in the collision operator. To avoid this mathematical difficulty, it was Grad's idea to cut the singularity. We will refer these cases as Grad's angular cut-off potential. The Boltzmann equation satisfies the conservation of mass, momentum and energy, and non-increasing of entropy, those physical properties will lead us get equilibrium state of the solution.

二、Mathematical theory for Boltzmann equation

Concerning the mathematical theory of the Boltzmann equation, it is nature to consider the solution near equilibrium. On the other hand, the nonlinear part usually decays faster than the linear part, so it is reasonable to drop the nonlinear part. We get the so called linearized Boltzmann equation after dropping the nonlinear part. For the study of the linearized Boltzmann equation, we can trace back to 1912, Hilbert [4] got the fluid structure of the linearized Boltzmann equation by using the expansion of the solution around a small Kundsen number, this expansion is the so called Hilbert expansion. We need to recognize that this kind of expansion is formal analysis and without mathematical proof. Concerning the mathematical structure of the linearized collision operator (spectrum structure), we do not have any result until Grad's paper in 1963. Grad got the explicit spectrum structure of the linearized collision operator for cutoff hard potentials case. After this result, the research of the Boltzmann equation improves very fast. For instance (only list the results relative to the author): Ukai (1974) [6] Perturbative solutions of the full inhomogeneous Boltzmann equation, based on the spectral theory of the linearized equation; Yan Guo (2002) [3] First of a series of works using energy methods to work out robust perturbative theories of the Boltzmann equation and other kinetic models; Liu-Yu (2004) [5] First works on the pointwise stability and Green function in the Boltzmann theory, and shock wave analysis; Gualdani-Mischle-Mouhot(2013) [2] Optimal rates of convergence for the Boltzmann equation in non-symmetric form.

三、Pointwise estimate

In general, the fundamental tools of the partial differential equation are energy estimate and Sobolev inequality. However, these kinds of methods will basically get the global norm estimate, but not localization estimate, i.e., the pointwise estimate. The first pointwise estimate of the linearized Boltzmann equation is hard sphere case, it was constructed by Tai-Ping Liu and Shih-Hsien Yu in 2004 [5], in their result, the solution of the linearized Boltzmann equation can be decomposed into the fluid part, the kinetic part and the remainder part. The crucial step of the construction is the so called "Mixture lemma", this lemma will transfer the velocity regularity to the space regularity. The original proof of the Mixture lemma need the explicit representation of the solution, this restriction can be replaced by the abstract method constructed by the author [7] (only need commutator analysis and energy estimate). Recently, the author (joint with Haitao Wang and Yu-Chu Lin) is able to construct the pointwise structure of the linearized Boltzmann equation for hard and soft potentials (need suitable velocity weight on the initial condition). We expect our ideas can apply to other important kinetic equations, for instance Landau equation; this will give more precise understanding of the kinetic theory.

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Enhancing immunogenicity of antigens through sustained intradermal delivery using chitosan microneedles with a patch-dissolvable design

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Microneedles (MNs) enable painless and efficient delivery of vaccines to the skin with the objective of targeting epidermal and dermal antigen-presenting cells (APCs) to induce an efficient immune response [1,2]. In this study, we report a patch-dissolvable embeddable MN system, composed of biodegradable chitosan MNs and a dissolvable supporting array patch, for complete and sustained delivery of encapsulated antigens to the skin **(Fig. 1)**. The supporting array can provide mechanical strength to fully insert chitosan MNs into the skin and then rapidly dissolve in skin interstitial fluid. After insertion, MNs could be directly implanted in the dermal layer as an intradermal (ID) depot to allow extended release of the model antigen ovalbumin (OVA) for up to 28 days. Using this system for sustained transdermal delivery minimizes patch wearing time, thus reducing skin irritation caused by long-term contact with transdermal adhesive or patches.

Targeted antigen delivery to the dermal layer that contains numerous APCs can induce stronger immunogenicity than can an intramuscular injection [3,4]. We found that rats immunized with MNs containing low-dose OVA (approximately 200 μg) had persistently high antibody levels for 18 weeks **(Fig. 2)**, which were significantly higher than those observed after an intramuscular injection of full-dose OVA (approximately 500 μg), demonstrating at least 2.5-fold dose sparing. Moreover, OVA-encapsulated chitosan MNs had superior immunogenicity to OVA plus chitosan solution, indicating that MN-based delivery and prolonged skin exposure can further enhance chitosan's adjuvanticity.

This is the first study to demonstrate the antigen dose-sparing potential of chitosan MNs. The use of low-dose vaccines is cost-effective and important for the safety of vaccine recipients because it can alleviate concerns associated with some adverse events caused by immunization. We expect that the patch-dissolvable MN system may serve as a new generation of transdermal vaccine delivery system to provide sustained immune stimulation and improve vaccine immunogenicity.

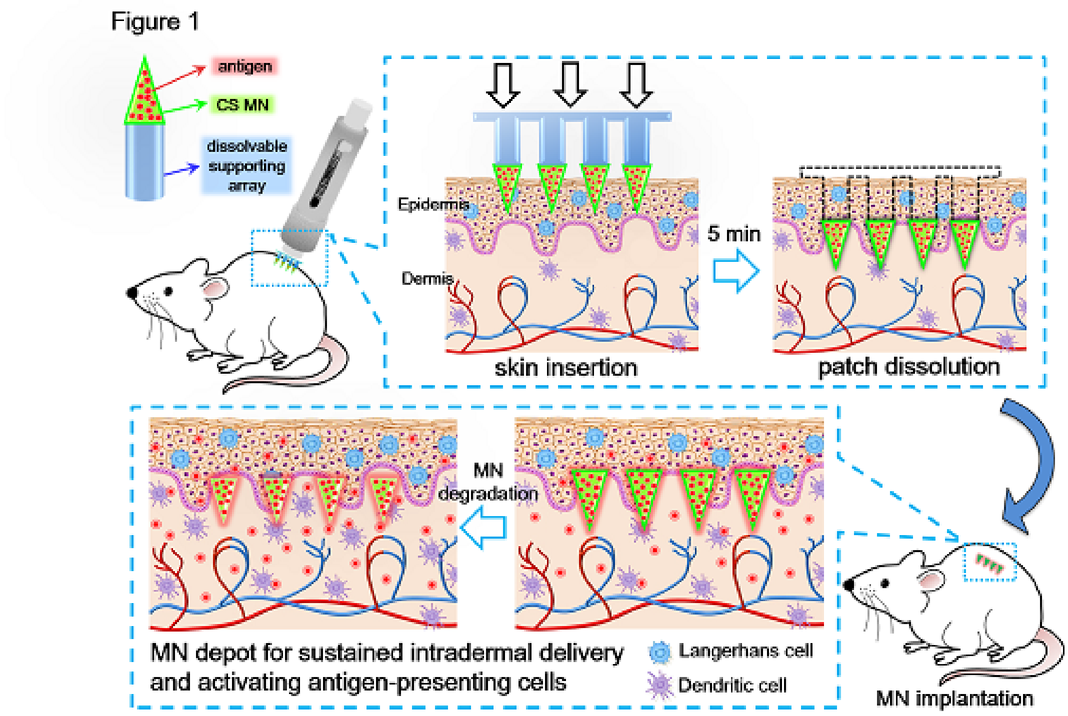

Fig. 1. Schematic illustrations of chitosan microneedles (MNs) with a patch-dissolvable design, consisting of antigen-loaded chitosan MNs and a dissolvable polyvinyl alcohol/polyvinyl pyrrolidone supporting array patch. After insertion, the supporting array can be quickly dissolved in the skin, thus implanting the MNs in the dermal layer as an intradermal (ID) depot to allow sustained release of the antigen and activating antigen-presenting cells.

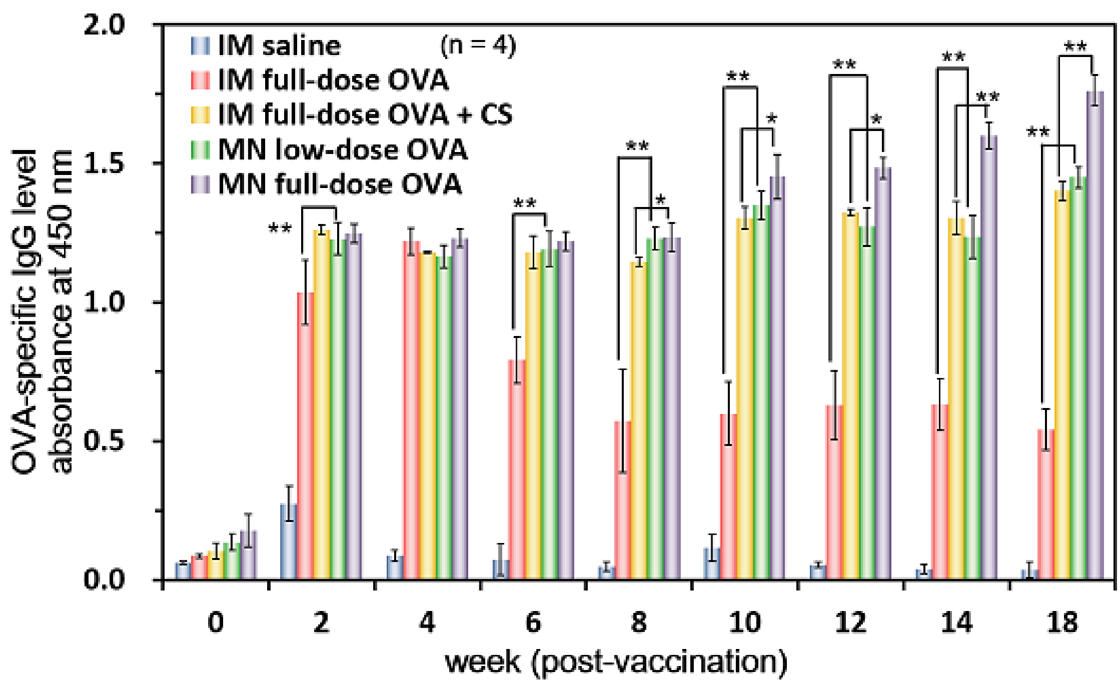

Fig. 2. OVA-specific IgG levels of rats after administration of a single dose of OVA on day 0: rats were intramuscularly injected with saline only (IM saline), or saline containing 500µg OVA (IM full-dose OVA), or 500µg OVA+1mg chitosan+0.1mg trehalose (IM full-dose OVA+CS); rats were received with MNs containing 200µg (MN low-dose OVA) or 500µg OVA (MN full-dose OVA) (n=4 rats for each group).

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