Surface Modification of Stratum Corneum for Drug Delivery and Skin Care by Microplasma Discharge Treatment

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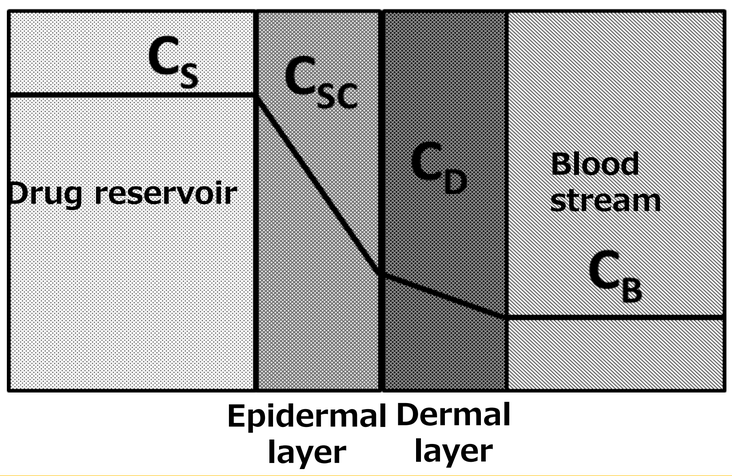
Introduction

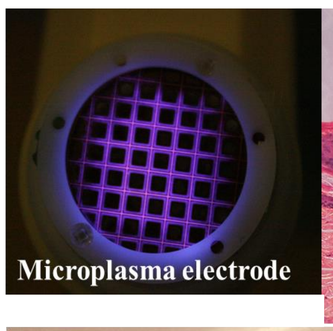
Stratum corneum is first barrier that protect our body and does not allow penetration of amount of objects such as drugs. Intercellular route is very often used for drug penetration when stratum corneum lipids are extracted or their structure is changed. Change of properties of the skin surface can change flow of transdermal drug delivery – if the drug is force to adsorb on the skin surface.

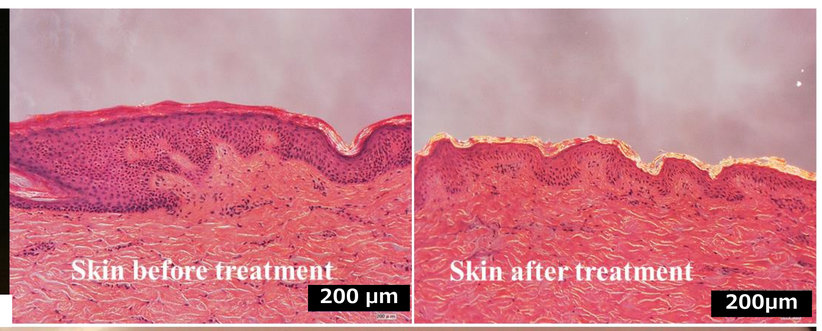
Drug delivery is given by:
1. **Concentration of drug in reservoir**
2. **Diffusivity in epidermal layer**
3. **Properties of vehicle (drug solvent)**

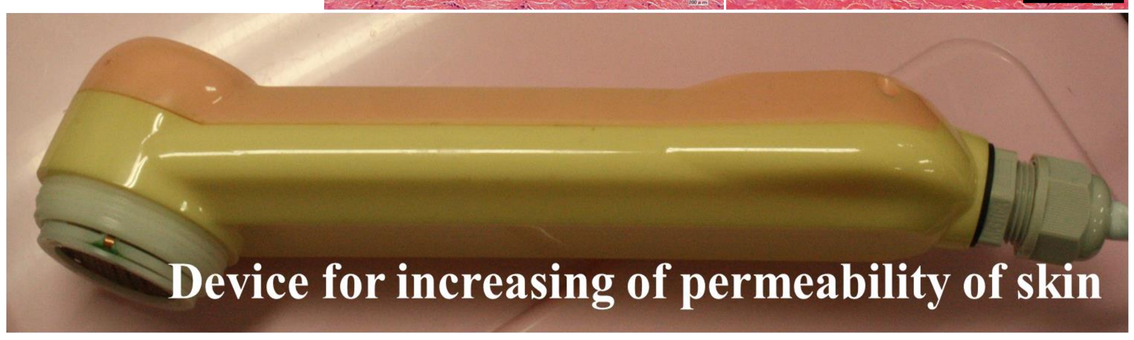


Experiment

Concentration of drug near surface can be change by surface properties – characterized by water contact angle

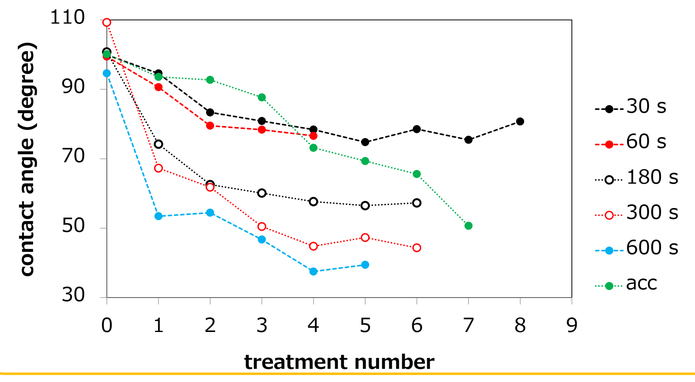






Plasma treatment of the skin can functionalize and increase of adhesion properties of the skin

Repeated treatment of the skin surface

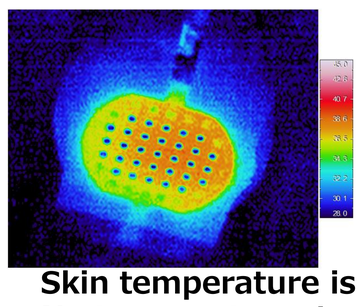


Inhomogeneity of treatment and free bonds decay very fast after plasma treatment

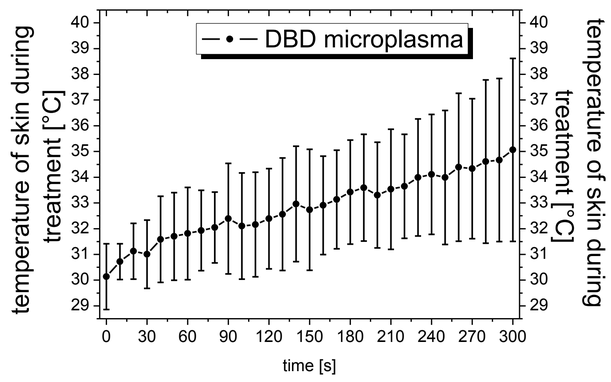
Skin treated the same time several times:
Slight decrease of contact angle

Temperature of plasma treated skin

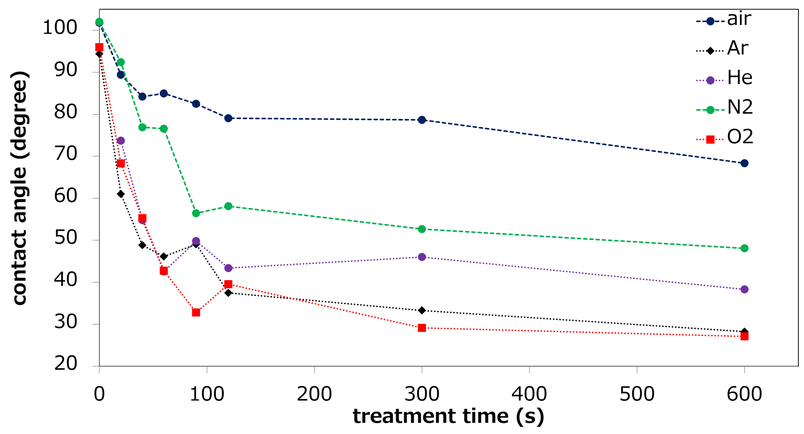
Ar microplasma discharge



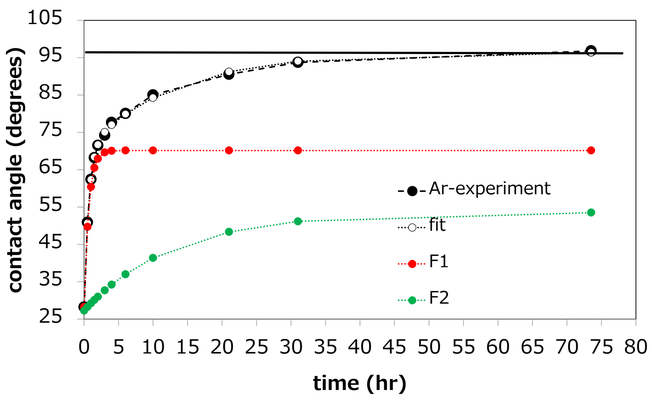
Skin temperature is under 45°C –
No temperature damage of the skin



Contact angle measurement Treatment time effectivity



Ar and O_2 plasma are the most effective when skin is in contact with electrode



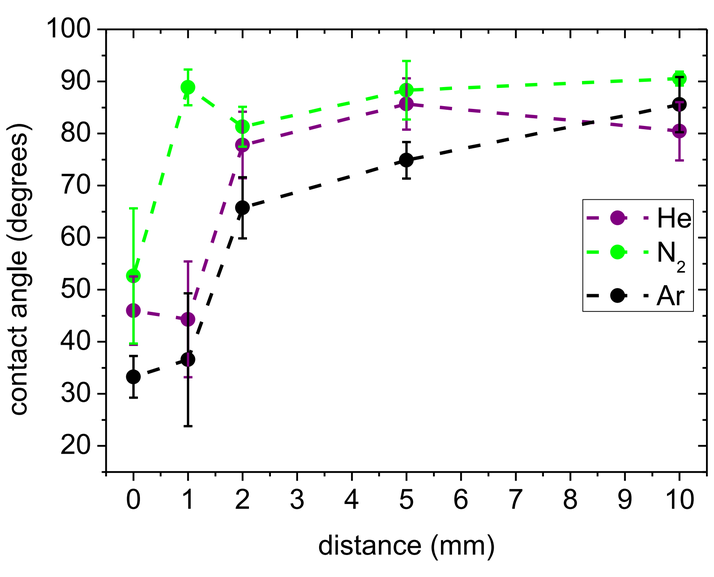
Ageing effect of plasma treated skin can be described by 2 exponential functions:
Fast increase – recovery from plasma treatment
Slow increase – drying process and evaporation of water molecules

Wet skin samples t_c~ 30-40 hours
Dry skin samples t_c ~10-15 hours
Fast increase (inverse correlated with contact angle)
t_b ~20-90 minutes

Ageing of contact angle:

$$CA(t) = A + B\left[1 - exp\left(-\frac{t}{t_B}\right)\right] + C\left[1 - exp\left(-\frac{t}{t_C}\right)\right]$$
$$= A + F1 + F2$$

Contact angle measurement Distance effectivity

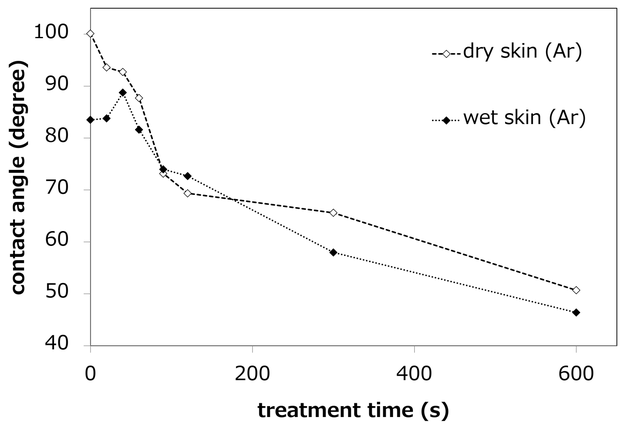


Contact angle of dry skin depending on treatment distance for He, N_2 and Ar plasma

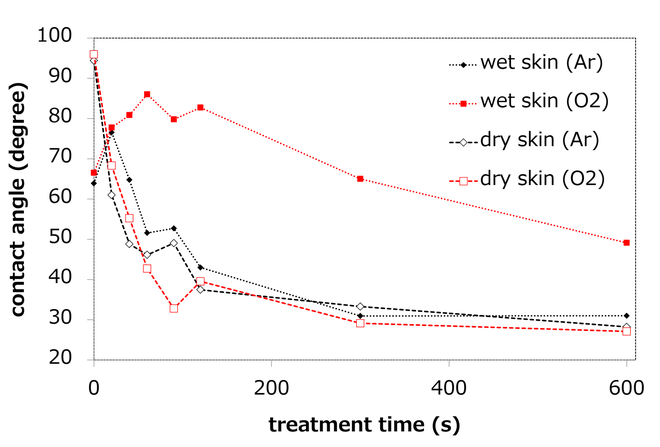
Skin covered by water after plasma treatment

Nonhomogeneous covered by water

Dry/Wet skin treatment

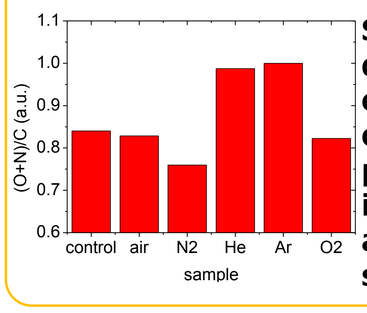


Skin treatment 1 mm from electrode

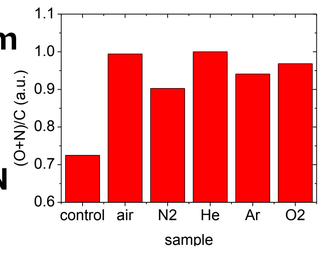


Skin treatment in contact with electrode

Atomic concentration on the skin surface



Skin treatment at distance 1 mm from electrode: only He and Ar plasma cause increase of O and N atoms on the skin surface



Skin treatment in contact with electrode: All plasma treated sample caused increase of O and N atoms on skin surface

Conclusions

- Microplasma irradiation increases water contact angle – the most efficient on surface on electrode by Ar plasma
- Roughness of the skin sample has minor effect on water contact angle (plasma treatment is nonhomogeneous)
- Ageing effect can be describe by decaying of plasma effect and drying of the skin sample
- Wet skin samples has lower water contact but after plasma treatment, contact angle is increasing due to water evaporation
- Microplasma treatment increase oxygen and nitrogen atoms on the skin surface