Electrostatic charging behavior of gelatin and HPMC hard capsules

Frank Thielmann,[1] Tomohito Nakao[2], Toshimitsu Usui [2], Tohru Kokubo[2] , Fernando Diez[3], Jerry Y.Y. Heng[4] , and Daniel Burnett[5]

[1]Novartis Pharma, PharmOps Stein, Switzerland
[2]Qualicaps Co Ltd, Nara, Japan
[3]Qualicaps Europe SAU, Alcobendas, Spain
[4]Department of Chemical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, UK
[5]Surface Measurement Systems Ltd., 2125 28th Street SW, Suite 1, Allentown, PA 18103, USA

BACKGROUND

Despite its high importance, electrostatic charging/ triboelectrification is still a poorly understood phenomenon in the pharmaceutical industry. Triboelectrification is caused by friction that occurs during transport, processing and testing and leads to formulation and manufacturing issues. Electrostatics also plays a major role in design and use of hard capsules. In this paper the impact of surface modifications of HMPC and gelatin capsules (via various lubricants) on triboelectric charge is investigated at different relative humidity conditions. This evaluation is complemented by a correlation to acid-base properties of the differently treated capsule types measured by Inverse Gas Chromatography (IGC).

MATERIALS AND METHODS

Triboelectric Charge Measurements

The following lubricants for surface modification were used: Calcium stearate, Magnesium stearate, Talc, Starch, Carnauba wax and Sodium lauryl sulfate. Lubricated and moisture equilibrated (at 12, 33 and 60% RH) sample capsules were electrically charged by putting them into a rotating friabilator rotated for 1 minute as shown in Figure 1 [1]. Afterwards charged capsules were measured in a Faraday cage by a Coulomb meter. The result was recorded at 0, 5 and 10 minutes after the initiation to also observe the charge decay. Sample size was 100 with 3 repeats. All capsules were provided by Qualicaps.

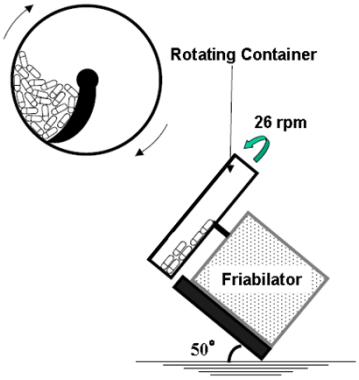


Figure 1. Experimental set-up to investigate tribocharging. The capsule samples are placed on a rotating friabilator and then measured in a Faraday Pail.

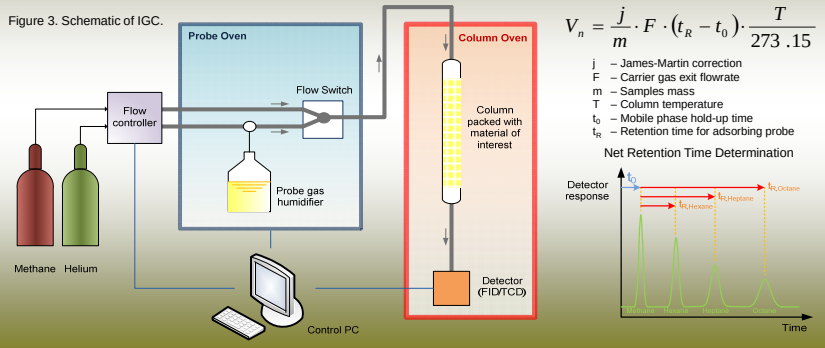
Surface Energy and Acid Base Properties by iGC Surface Energy Analyser

Since a major contribution to triboelectrification is due to a migration of electrons during contact/ friction between two different surfaces, it was postulated in literature that an estimation of the triboelectrification behavior can also be obtained by the determination of the acid-base properties of a material under investigation [2,3].
Inverse Gas Chromatography has been proven as a useful and easy-to-use approach to determine the surface energy and acid-base properties of pharmaceutical powders.
Acid-base measurements on the capsules used in this study were carried out using the surface energy analyser (SEA) by Surface Measurement Systems, UK. Measurements were carried out at finite concentration and acid-base values were determined from the maximum of the energy distribution [4]

(iGC SEA, Surface Measurement Systems, UK)

- Provide surface energy profiles of particulate/fibrous samples unlike conventional techniques which only yield a single average valued property [5];
- *Known* vapor probes to characterise *unknown* solid sample with both dispersive and polar probes.
- *Retention time t_R / volume V_n is directly related to surface energy. The higher the time, the stronger the interaction, the more energetic the surface.*

Figure 3. Schematic of IGC.



$$V_n = \frac{j}{m} \cdot F \cdot (t_R - t_0) \cdot \frac{T}{273.15}$$

j – James-Martin correction
F – Carrier gas exit flowrate
m – Samples mass
T – Column temperature
t_0 – Mobile phase hold-up time
t_R – Retention time for adsorbing probe

Net Retention Time Determination

RESULTS AND DISCUSSIONS

Triboelectric charge measurements

Figure 2 shows the 14 capsule types investigated and the charge values measured by Faraday Pail as function of humidity.

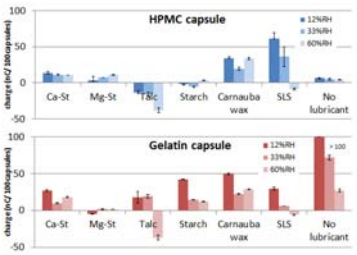


Figure 2. Charge measured as a function of storage humidity and lubricant type.

Some lubricants are known to work as antistatic agents. The presence of moisture accelerates the transfer of electric charges. HPMC capsules charged less than gelatin capsules at all humidities, even without lubrication. Measurements of charge after different time periods didn't show any significant difference for most samples (not shown). However, charge decay was not expected due to the electrical insulation of the Faraday cup.
Gelatin capsules were significantly charged by friction with the acrylic container. At 12% RH the static charge exceeded 100 nC/100 capsules, and decreased as the humidity increased. Lubricants were effective in reducing the triboelectrification of gelatin capsules. Corn starch was the most effective lubricant in suppressing static charge for HPMC capsules and magnesium stearate worked best for hard gelatin capsules in our system (capsule – lubricant – acrylic)

IGC acid-base measurements

IGC measurements were carried out on HPMC capsule samples. Table 1 shows the dispersive and, specific surface energy values as well as acid-base contributions (according to the van Oss approach [6]) for the different lubricant types investigated.

	gammaAB	gammaD	gamma+	gamma-
CaSt	5.5	27.6	0.47	3.26
SLS	3.3	26	0.37	3.26
Talc	12.6	42	0.74	4.46
MgSt	7.6	24	0.50	4.24
Starch	8.9	39	0.54	3.91
C. Wax	5.2	31	0.08	1.99

Table 1. Dispersive and specific surface energy as well as acid and base contribution values obtained using IGC for the HMPC capsule types under investigation.

While in previous papers a good correlation between base contribution [6] or base/ acid ratio [2, 3] have been reported, there was no direct correlation found of either parameter in this study. However, the specific surface energy increased with decreasing charge as shown in Figure 3.

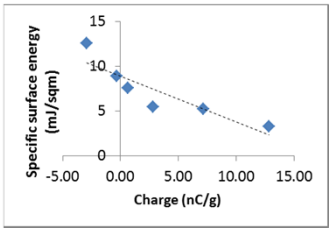


Figure 3. Correlation of specific surface energy values obtained using IGC with electrostatic charge measured by Faraday Pail for the HPMC capsules under investigation.

This result was surprising at first glance. It can be speculated that the decrease in specific surface energy and therefore polarity of the capsule surface leads to a stronger isolator character of the sample which causes more triboelectrification.
The fact that no direct correlation to the acid-base parameters was observed is probably due to the more complex nature of such composite system that does not allow for a simple prediction as discussed in previous studies.

CONCLUSIONS

1. Lubricants used for surface modification of capsules showed a strong impact on electrostatic charging for both HPMC and gelatin capsules.
2. Specific surface energy decreased with increasing electrostatic charge that is most likely due to the increasing isolator character of the capsule surface causing more triboelectrification.

REFERENCES

[1] Sakuma, S et al., *AAPS Poster (2003).*
[2] Hawkins, M. et al, *J. Imag. Sci. Techn.* 50 (2006), 288.
[3] Ahfat, M.N. et al, *European Journal of Pharmaceutical Sciences* 9 (2000) 271–276.
[4] Thielmann, F., DJ Burnett and J.Y.Y Heng, *Drug Dev. Ind. Pharm.* **33**, 1240-1253 (2007).
[5] Grimsey, I.M. et al, *J. Pharm. Sci.* 91 (2002) 571-583.
[6] van Oss, C., Good, R. and Chaudhury, M., *Langmuir* 4 (1988), 884.
[7] Thielmann, F et al., *AAPS Poster* (2012).