TANNPAPIER

Simulating the Lip-Release Effect of Tipping Paper and its Influence on the End Use Application of Cigarette Products

by

Michael Lindner, TANNPAPIER GmbH, Austria

Introduction

- **Tipping paper:** Chemical surface treatment in order to provide for efficient lip-release properties → lip-release coating / printing inks containing lip-release substances (e. g. nitrocellulose)

- Lip-release efficiency depends on

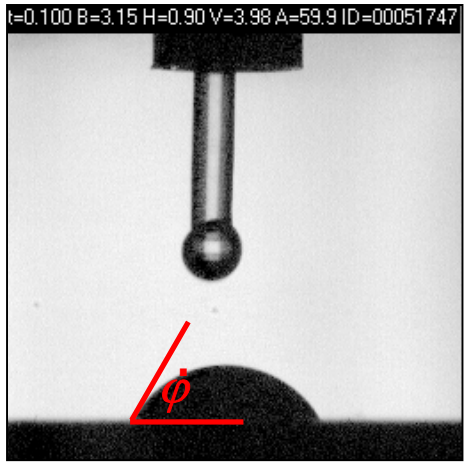
  - coating / printing process parameters (rotogravure printing cylinder data)

  - physical base paper specifications

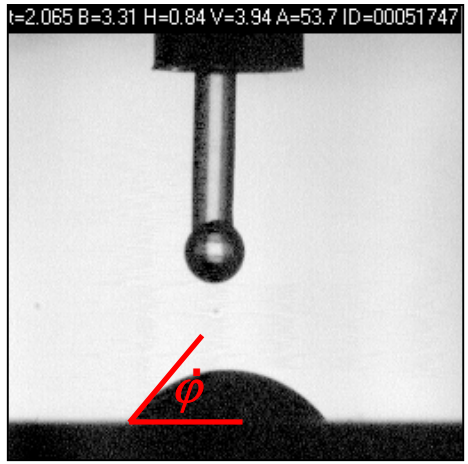
  - chemical base paper composition

Absorption Test Methods

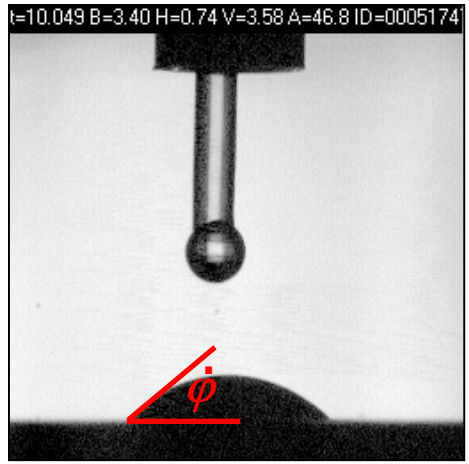
- Dynamic contact angle measurement:



0,1 seconds after drop deposition



2 seconds after drop deposition

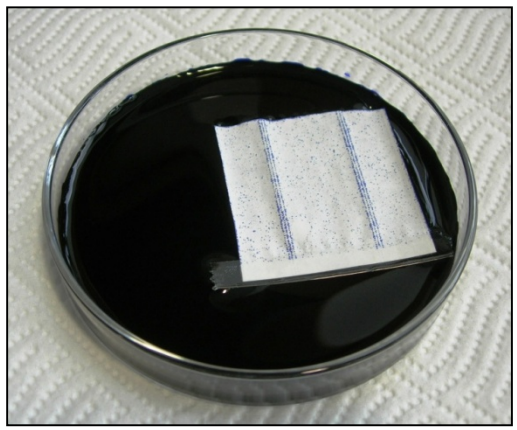


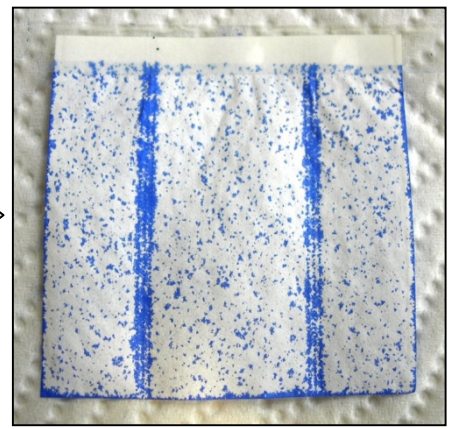
10 seconds after drop deposition

$$\dot{\varphi} = \frac{\Delta\varphi}{\Delta t}:$$

Dynamic contact angle

- Ink floating test:

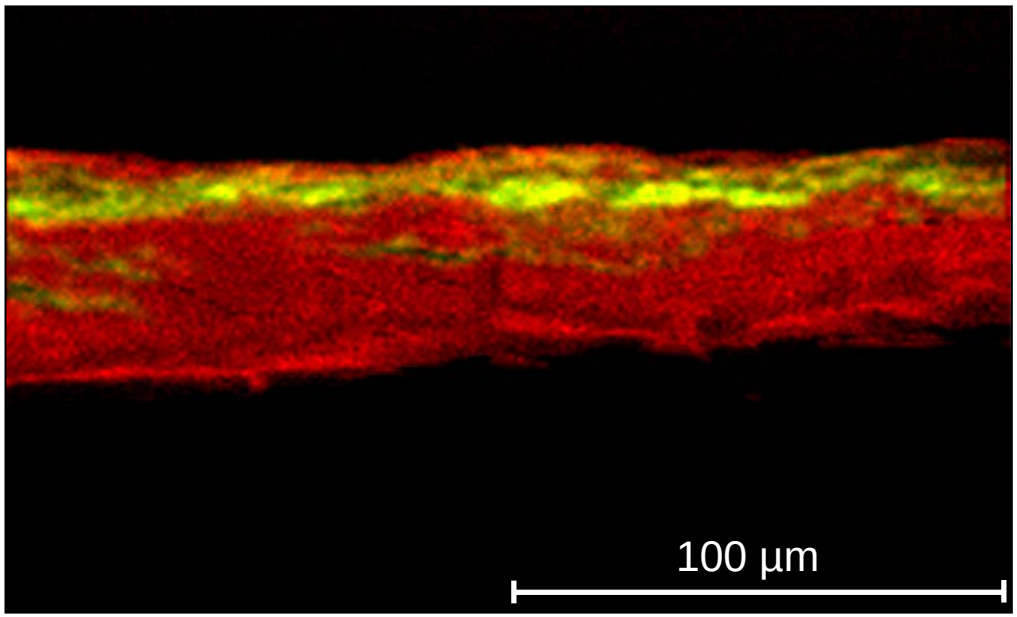




Result on the uncoated / unprinted side of the tipping paper

Absorption Principle

- Tipping paper SIMS cross-section analysis:



Lip-release layer („barrier“):
Primary absorptivity = absorption affinity → lip-release efficiency

Secondary absorptivity = absorption speed

- First, the liquid gets slowly absorbed by the lip-release barrier
- Subsequently, the liquid transport becomes accelerated by the pure base paper material
- Macroscopic description and simulation of the tipping paper absorptivity with an empirical mathematical model → prediction and calculation of the expected theoretical lip-release quality prior to the tipping base paper converting process

Absorption Model

- Dynamic contact angle:

$$\Delta\theta(t) = \int_{d_1}^{d} \frac{\eta\sigma}{\sqrt{\pi\alpha t}} \left[e^{\left(-x^2/4\alpha t\right)} + \sum_{n=1}^{\infty} r^n e^{\left(-(2nd-x)^2/4\alpha t\right)} + r^n e^{\left(-(2nd+x)^2/4\alpha t\right)} \right] dx$$

σ: Surface tension of water
η: Mass density of the lip-release solution
d: Base paper thickness
α: Primary absorptivity
r: Secondary absorptivity
d_1: Thickness of the lip-release layer

$$\alpha = c_\alpha \cdot \frac{(d_1^2 + 1) \cdot P}{\sqrt[4]{S} \cdot KW_{5\_calc} \cdot \rho} \qquad r = c_r \cdot \frac{\sqrt[4]{S} \cdot \rho}{\sqrt{d - d_1} \cdot KW_{5\_calc}} \qquad d_1 = c_{d1} \cdot \frac{ED}{\sqrt{P \cdot s} \cdot KW_{5\_calc}}$$

P: Base paper porosity
S: Level of sizing
ρ: Base paper mass density
s: Base paper surface smoothness
ED: Etching depth of the rotogravure cylinder
c_α, c_r, c_{d1}: Constant prefactors
KW_{5_calc}: Calculated base paper static contact angle @ 5 sec.

Absorption Model

- Static contact angle:

$$KW_{5\_calc} = c_{KW5} \cdot \sqrt[8]{S} \cdot \sqrt[4]{P} \cdot \left(C_{ta} + \sqrt{C_{ca}} + C_{cc} + C_{al} + C_{si} + C_{ti} + C_{st}^{2} \right)$$

c_{KW5}: Constant prefactor
C_{ta}, C_{ca}, C_{cc}, C_{al}, C_{si}, C_{ti}, C_{st}: Content of talcum, calcium carbonate, China clay, aluminium hydroxide, silicate, titanium dioxide, starch

- Plain cork tipping paper:

$$KW_{5\_calc} = c_{KW5} \cdot \sqrt[8]{S} \cdot \sqrt[4]{P} \cdot \left(C_{ta} + \sqrt{C_{ca}} + C_{cc} + C_{al} + C_{si} + C_{ti} + C_{st}^{2} + C_{iox}^{2} \right)$$

C_{iox}: Iron oxide content

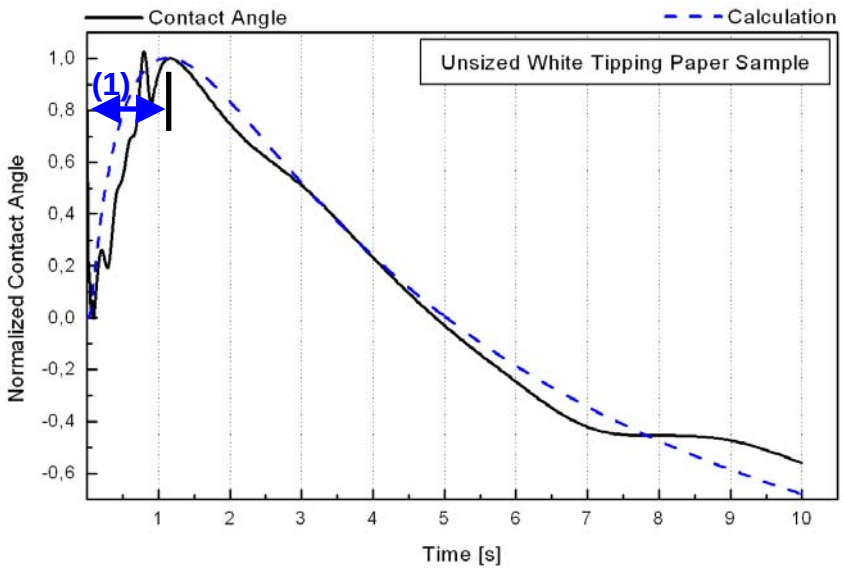
- Tipping paper with pigment (color) overprint:

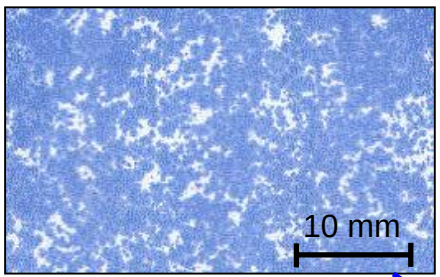
$$d_1 = c_{d1} \cdot \frac{ED}{\sqrt{P \cdot s} \cdot KW_{5\_calc} \cdot \sqrt[8]{C_{pigm}}}$$

C_{pigm}: Pigment content in the printing ink

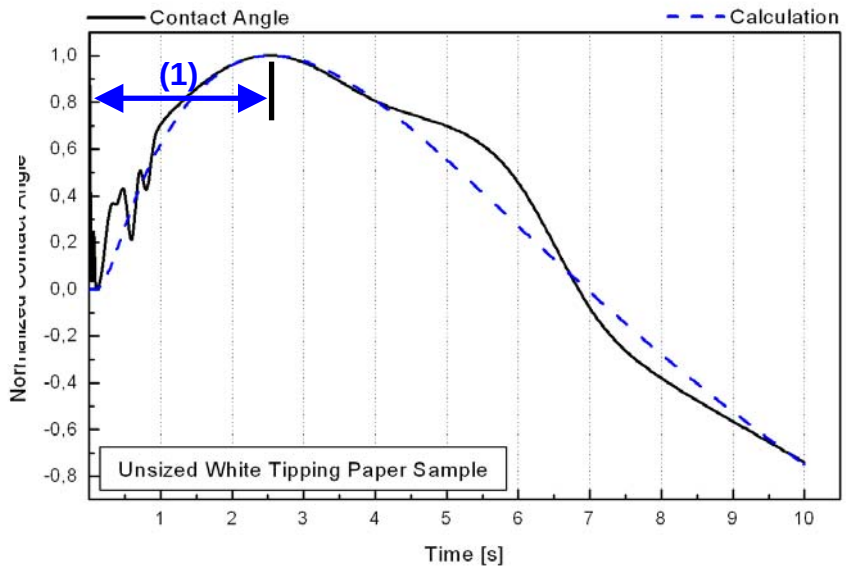
Absorption Simulation

- Dynamic contact angle – white tipping paper :

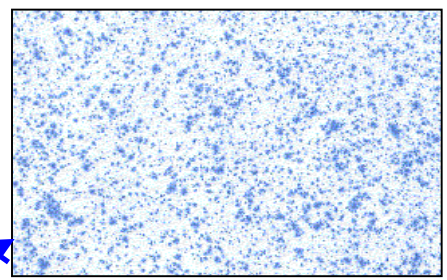




Increase of the dynamic contact angle corresponds to primary absorptivity (1) which is directly related to the lip-release efficiency

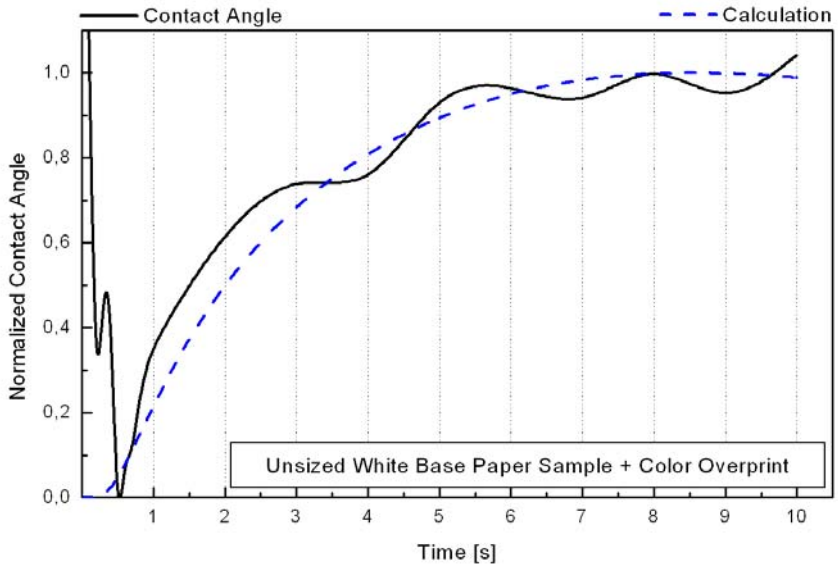


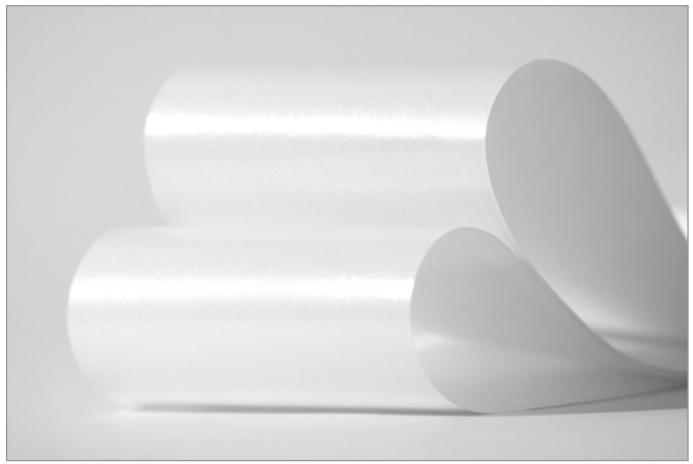
Ink floating test results demonstrate the influence of the base paper properties on the tipping paper absorptivity

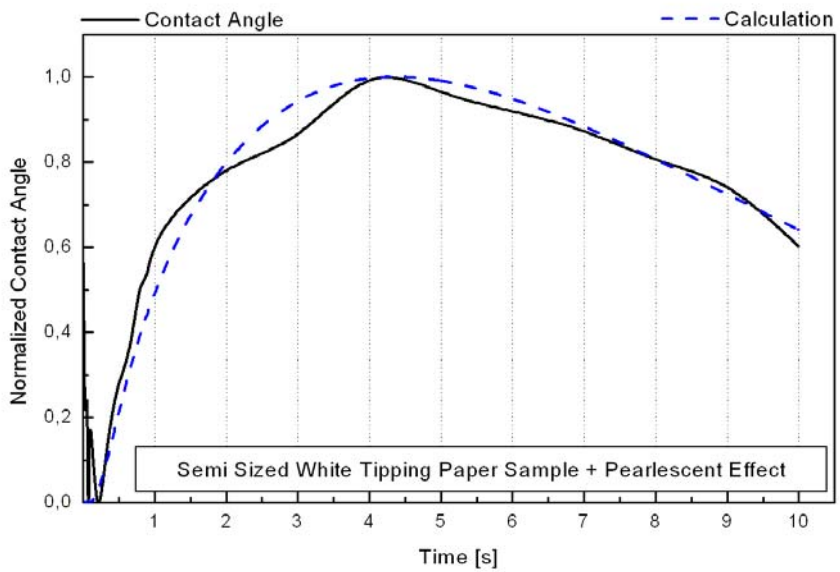


Absorption Simulation

- Dynamic contact angle – tipping paper with color / special effect overprint:







Smoking Sensation

- The physiological perception of the lip-release properties is subjective and depends on the individual smoking habits of cigarette smokers

- Smoking sensation is influenced by

  - the smoker‘s state of health and the emotional state
  - the time of the day
  - climatic conditions of the smoker‘s environment
  - the prior to smoking consumed types of food and beverages
  - etc.

- Selection of tipping paper qualities: Survey amongst regular cigarette smokers and with a professional smoker panel → correlation between the calculated lip-release efficiency and the real sensation on the human lips

- Investigation target: Possibility to adapt the lip-release quality during the tipping paper production to specific requests of cigarette consumers

Sample Selection

Zigarette weiss

White Tipping Paper Samples

Sample Number	Sizing	Grammage [g/m²]	Thickness [µm]	Density [kg/m³]	Smoothness [Bekk-Sec.]	Porosity [CU]
1	Unsized	36	46	782,6	80	10,8
2	Unsized	36	41	878,0	200	6,4
3	Unsized	36	37	973,0	200	2,3
4	Unsized	36	33	1090,9	650	1,7
5	Semi Sized	36	45	800,0	100	8,4
6	Unsized	33	34	970,6	200	2,2
7	Fully Sized	32	36	888,9	200	3,3

- Tipping paper samples for testing purposes on a laboratory scale
- Production of cigarettes for the surveys on a commercial cigarette machine: American Blend tobacco, 275 ventilated cigarette sticks / tipping paper quality

Survey amongst Regular Smokers

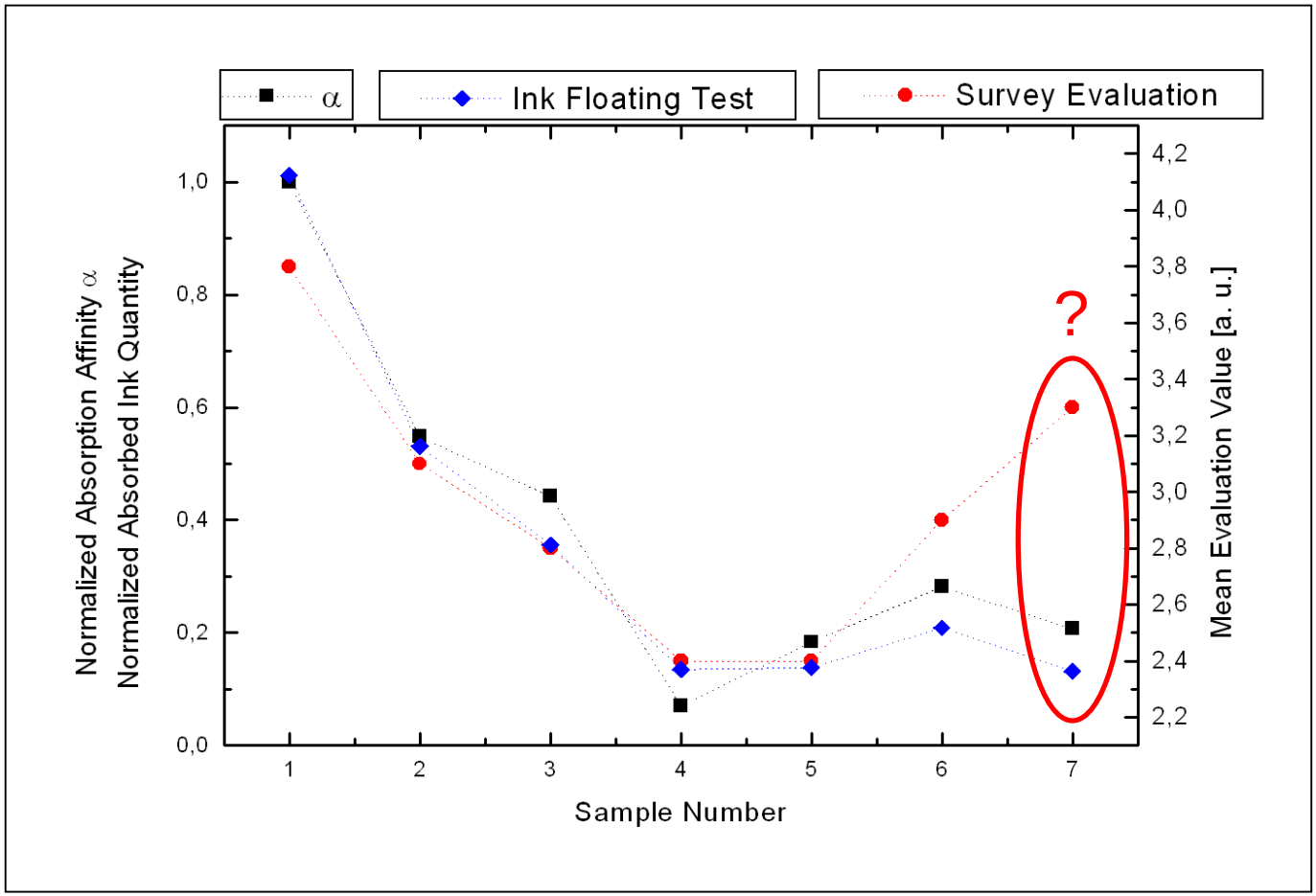
- 55 people, who smoke cigarettes regularly, were questioned
- Each candidate was provided with 2 cigarette sticks / tipping paper quality
- The participant was requested to evaluate the stickiness / adhesion of the tipping on the lips while smoking the cigarette with numbers from 1 to 10, where

  1… Absolutely no adhesion of the tipping on the lips

  10… Tipping sticks on the lips and can only be removed painfully

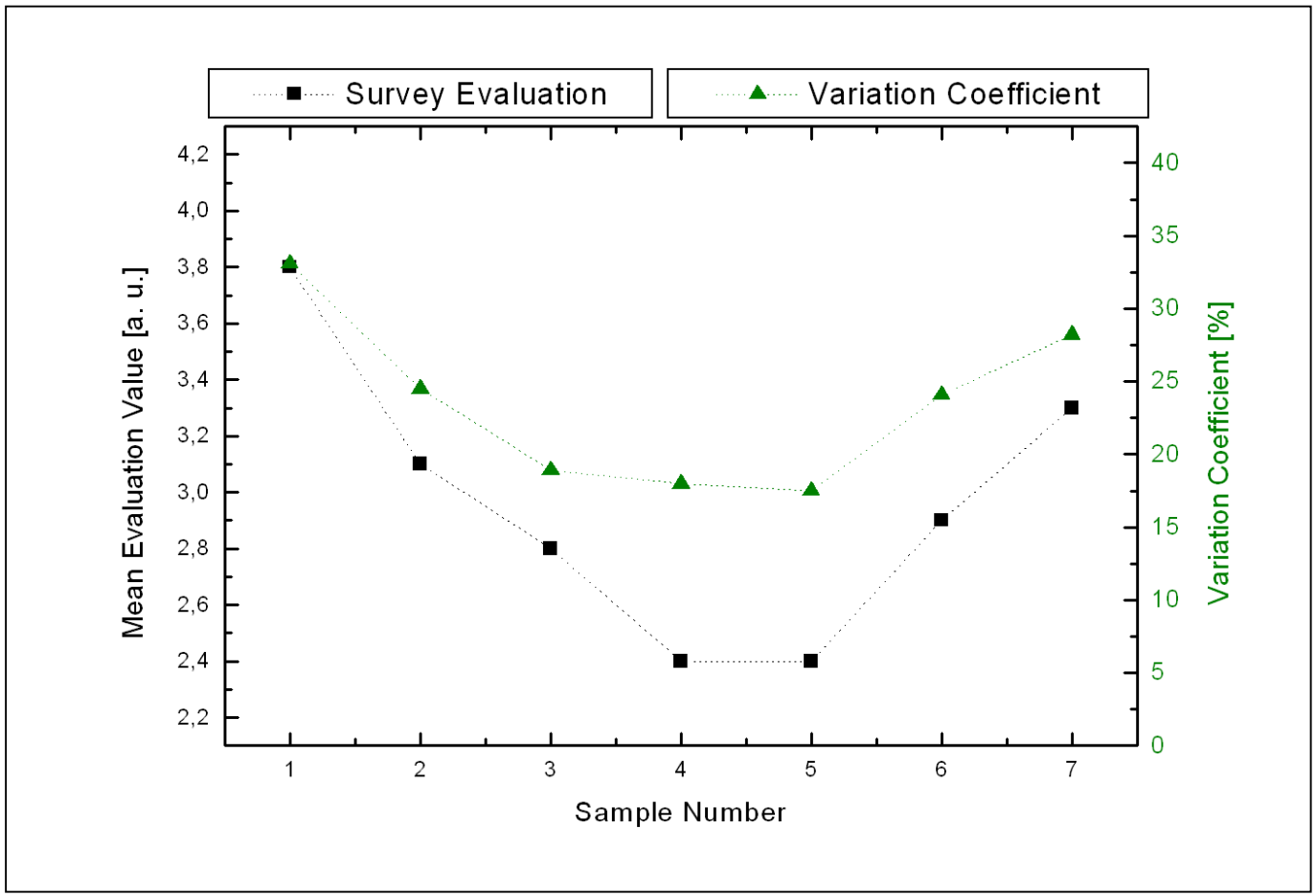
- Statistical evaluation of the survey data + comparison with the primary absorptivity α and ink floating test results

Survey amongst Regular Smokers



- Good correlation between the primary absorptivity α, the soaked ink quantity and the human lip-release sensation except for sample number 7 → explanation follows

Survey amongst Regular Smokers



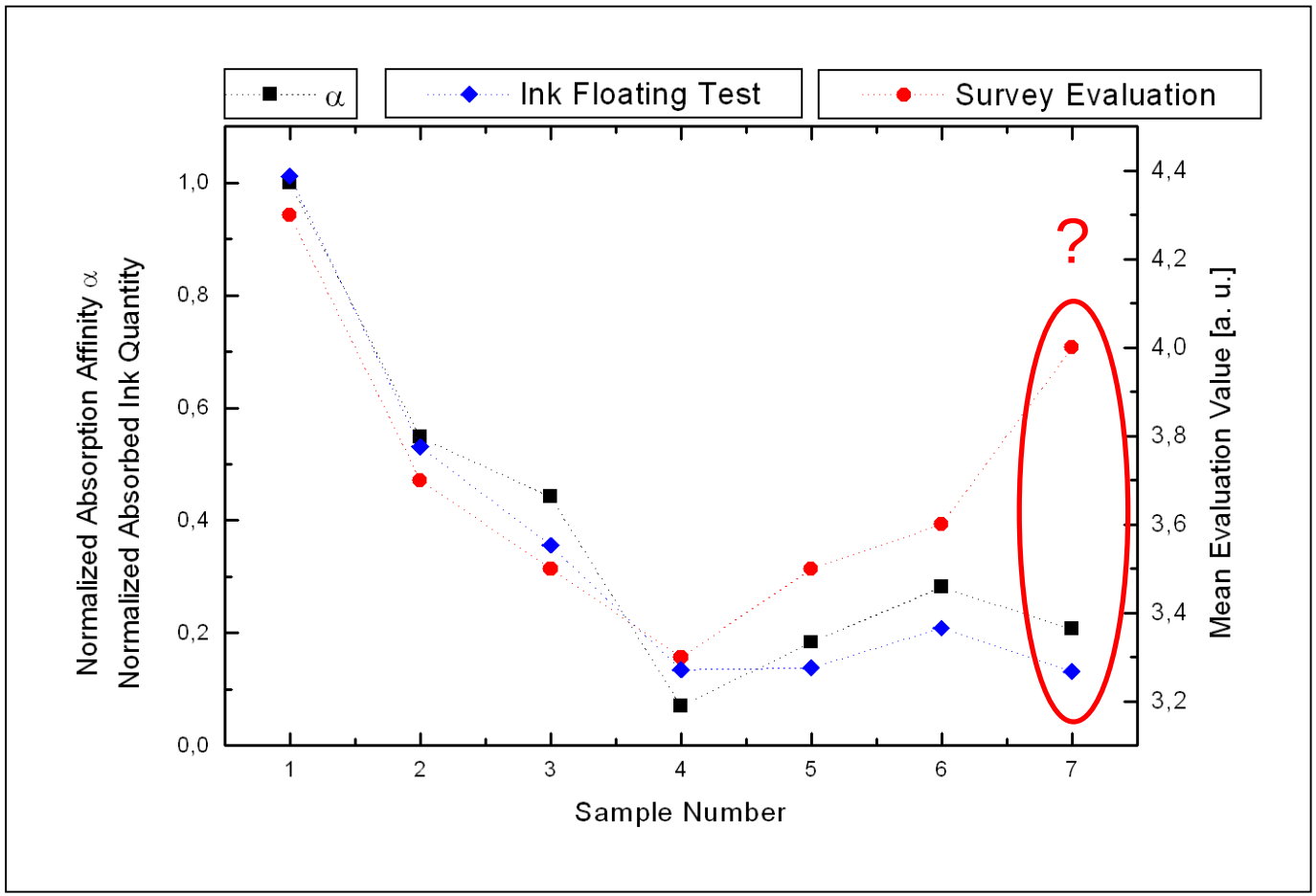
- With higher adhesiveness, the subjective differentiation of the lip-release efficiency becomes more difficult → the variation coefficient increases

Survey among STC Smoker Panel

- 10 professional cigarette smokers from Shanghai Tobacco (Group) Corporation (STC)[1)]
- Each candidate was provided with 2 cigarette sticks / tipping paper quality
- The same evaluation criteria were valid as for the survey amongst regular smokers
- Statistical evaluation of the survey data + comparison with the primary absorptivity α and ink floating test results

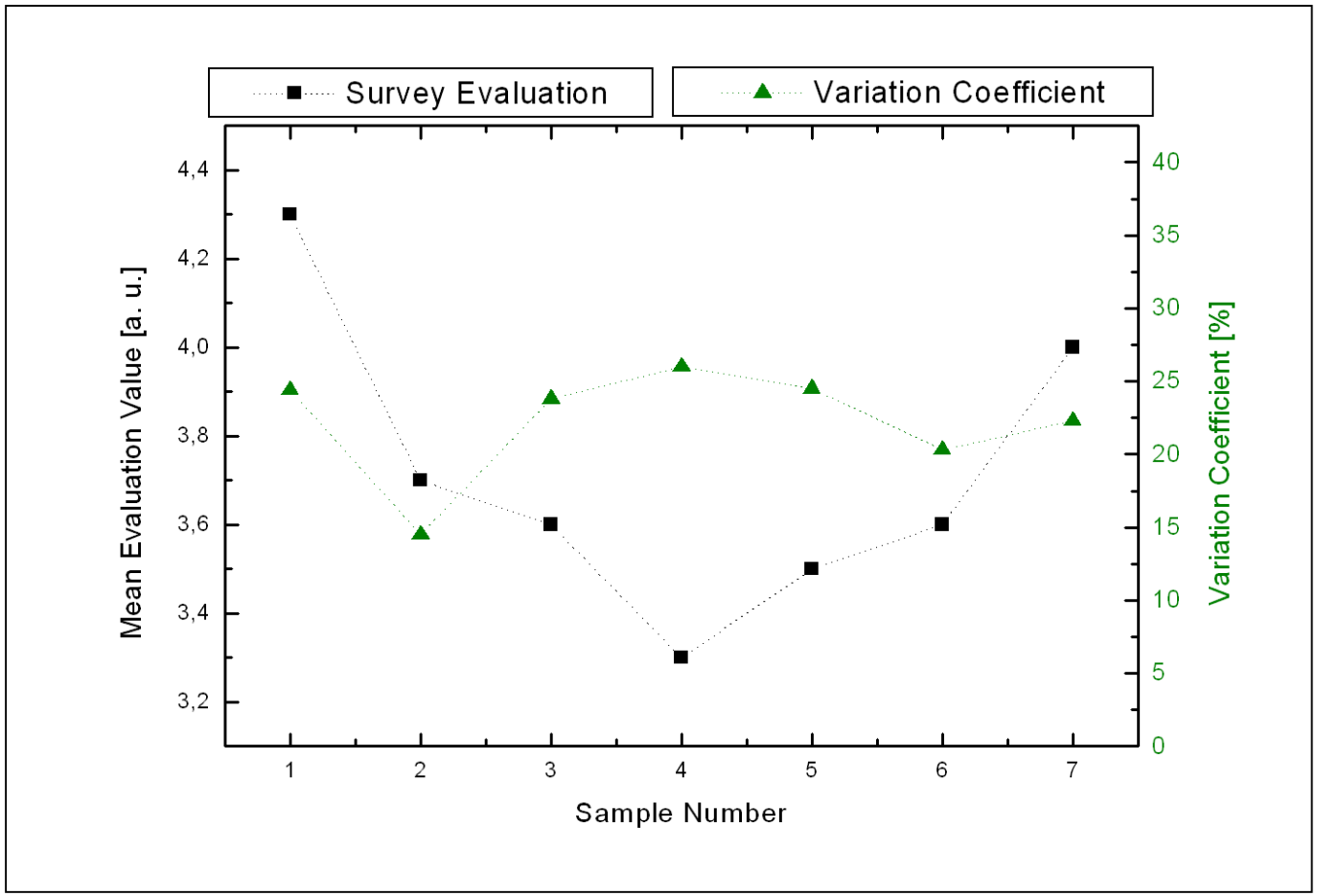
[1)]Thanks to Mr. LU You and Mr. CHEN Daifeng from STC for providing me with the smoker panel.

Survey among STC Smoker Panel



- Good correlation between the primary absorptivity α, the soaked ink quantity and the human lip-release sensation except for sample number 7 → explanation follows

Survey among STC Smoker Panel



- Practically no tendency in the variation coefficient → people from the smoker panel show comparable smoking habits and perception

Sample Number 7

- Contrary behavior between the lip-release sensation and the simulation / experimental results
- Smoking sensation indicates pretty high adhesiveness, model and test reveal rather low stickiness
- Sample number 7 is fully sized (i. e. content of sizing agent is relatively high)

→ Human saliva on the smoker‘s lips activates distinctly the sizing agent

→ Interaction between the lips and the sizing agent

→ A part of the total adhesive perception is caused by this interaction and not by absorption

- Interaction can be neglected for semi-sized tipping paper

Summary

- Calculation and simulation of the lip-release properties of coated or printed tipping base paper with an empirical, macroscopic model

- Simulation results are in a good agreement with experimental methods to determine the water absorptivity of tipping paper

- Surveys amongst regular smokers and among a professional smoker panel on the subjective perception of the lip-release efficiency on the human lips with sample cigarettes

→ Model output delivers a reliable interpretation of the expected tipping paper lip adhesiveness

→ Reduction of the simulation accuracy with fully sized base paper which is hardly applied any more in cigarette industry

→ Lip-release model opens the potential to predict the quality of the lip-release properties prior to tipping paper production especially for specific target groups of cigarette consumers