TAMPERE UNIVERSITY OF TECHNOLOGY
Institute of Paper Converting

The Effects of Corona and Flame Treatment: Part 1. PE-LD Coated Packaging Board

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Introduction

- Extrusion coated paperboards are applied successfully especially in packaging industry
- Packaging product requires special surface properties from the materials, which extrusion coated paperboards often do not possess, such as printability and heat sealability
- Several methods have been developed to modify surface properties, including flame, corona, and plasma treatments
- These methods affect the surface energy, oxidation, heat sealability and printability of surfaces, but how?

Introduction

- The effects of flame and corona treatment on surface energy have been examined continuously up to eight months
- The effects of flame and corona treatments on oxidation, heat sealability, hot tack and printability are evaluated (right after treatment vs. six months later)
- The co-effect of flame and corona treatments is studied, (surface energy, heat sealability, and printability)
- In addition, the influence of the treatment order, i.e. which of the treatments (flame or corona) is applied the first, (surface energy, heat sealability, and printability)

Experimental

- In this study, 205 g/m^2 paperboard was extrusion coated with 15 g/m^2 of PE-LD at pilot line of TUT (Institute of Paper Converting)
- Flame and corona treatment were used to modify surface of PE-LD coated paperboard
- Surface energies were defined with contact angle measurements (Pocket Goniometer PG-3)
- Surface oxidation and chemical composition was defined with ESCA (Electron spectroscopy for chemical analysis) and ATR-FTIR (Attenuated Total Reflection using Fourier Transform Infrared Spectroscopy)
- Heat sealing and hot tack properties were defined with KOPP Laboratory Sealer SGPE 20 measuring system

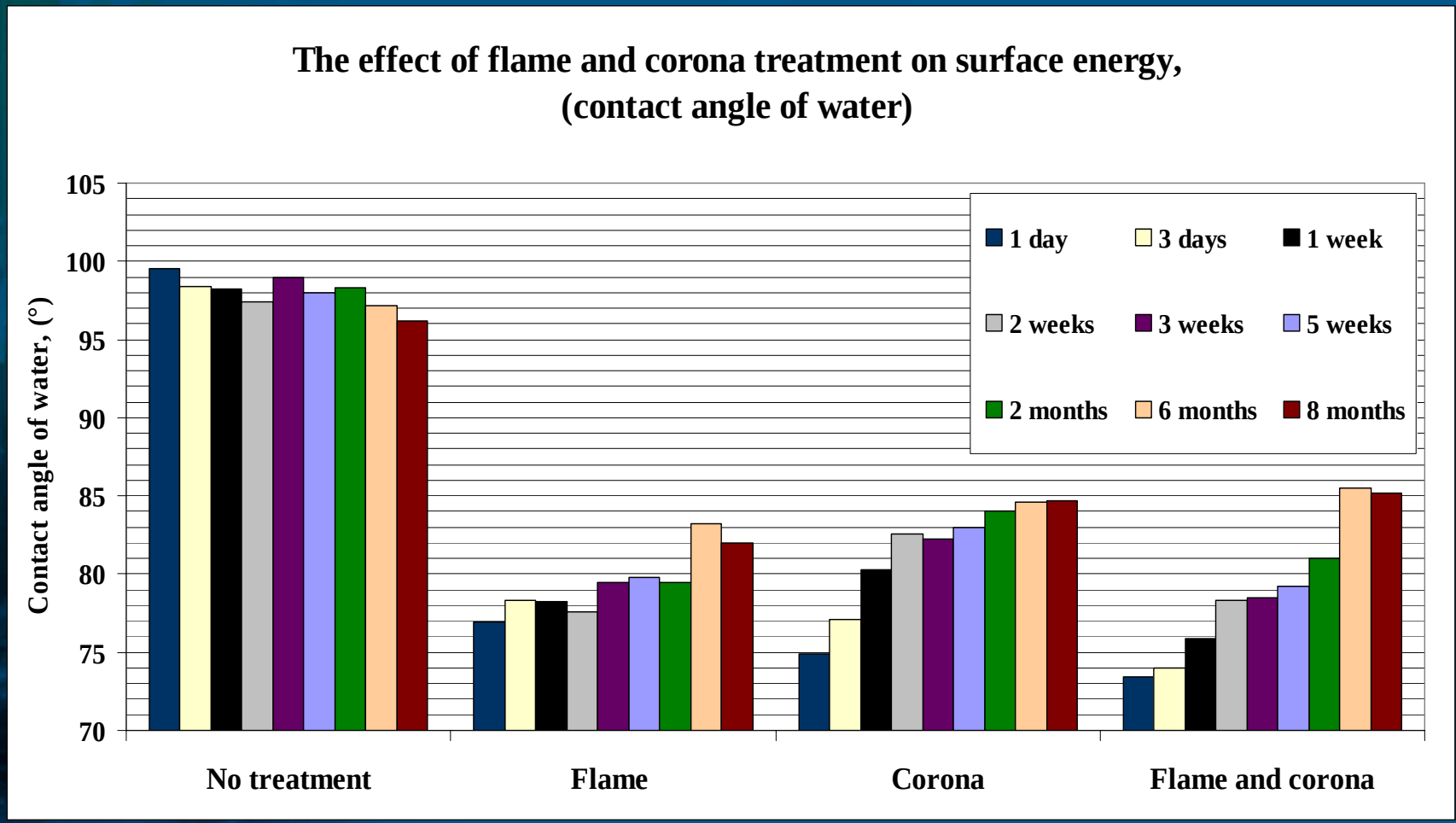
Experimental

- The samples were printed with a Xeikon DCP/50-SP digital printing machine
- The printing method in the Xeikon is based on a dry toner web fed electrophotographic process
- Toner adhesion was defined with a rub-off measurement
- Print quality, mainly print mottle, was analyzed both visually (ranking list) and numerically (mottle value)

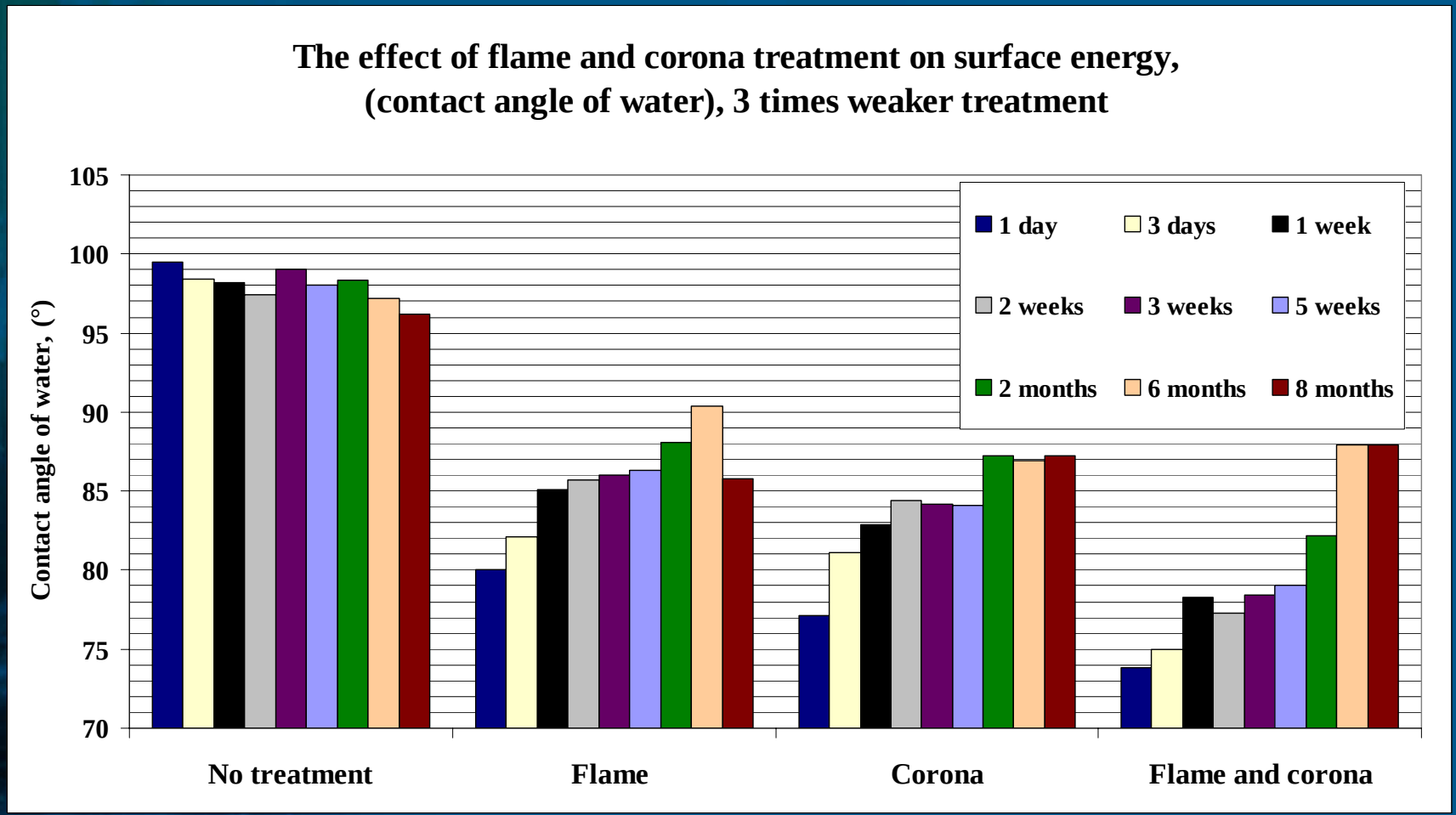
Results

- Surface energy
  - The influence of treatment efficiencies and treatment order
- Heat sealability i.e. heat sealing and hot tack temperatures
  - The influence of treatment efficiencies and treatment order
- Printability
  - Visual quality (ranking 1-5) and toner adhesion (rub-off)
  - The influence of treatment order
- Oxidation and chemical composition
  - ESCA and ATR-FTIR
  - The influence of treatment order

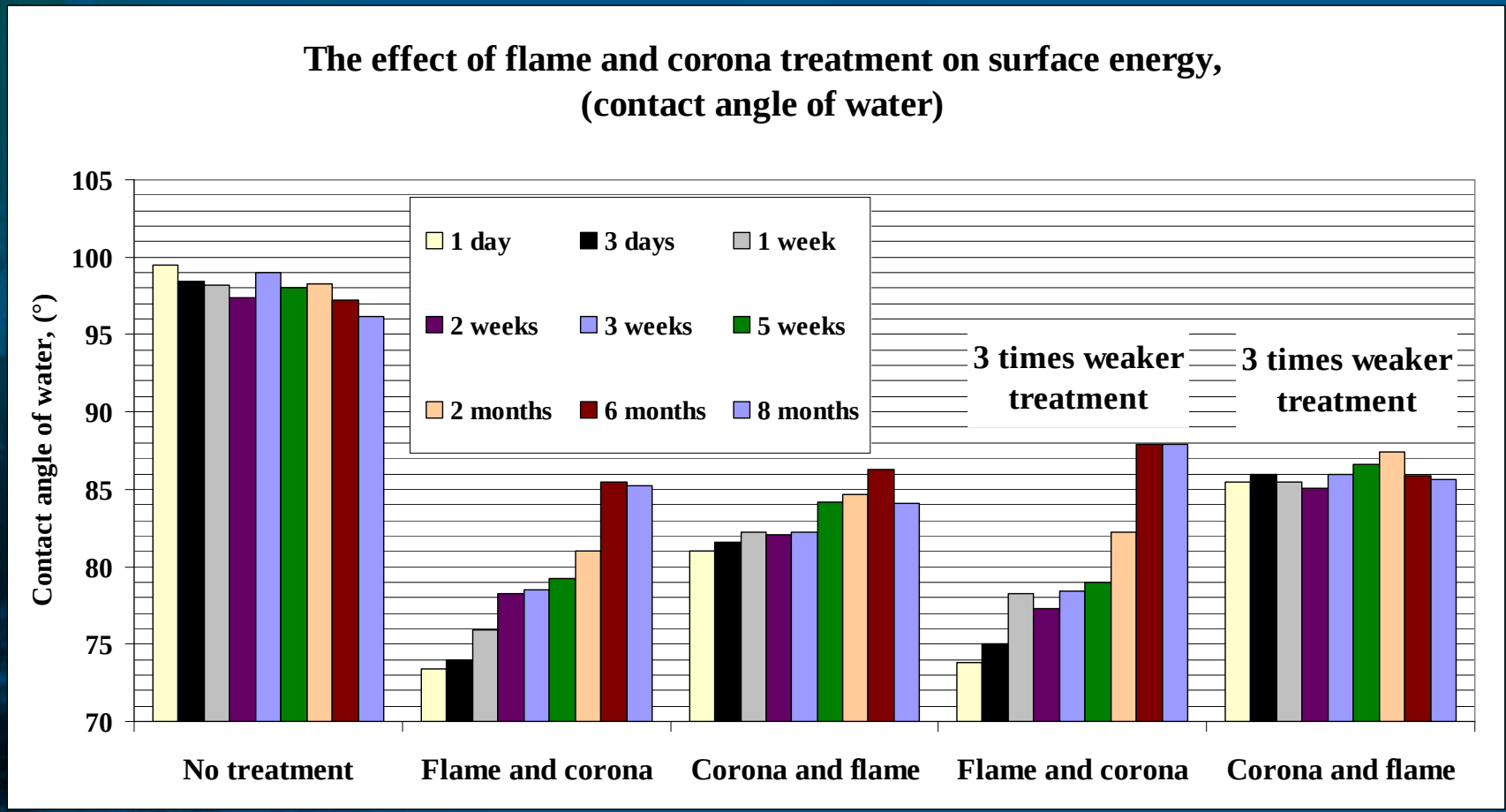
Surface energy



Surface energy



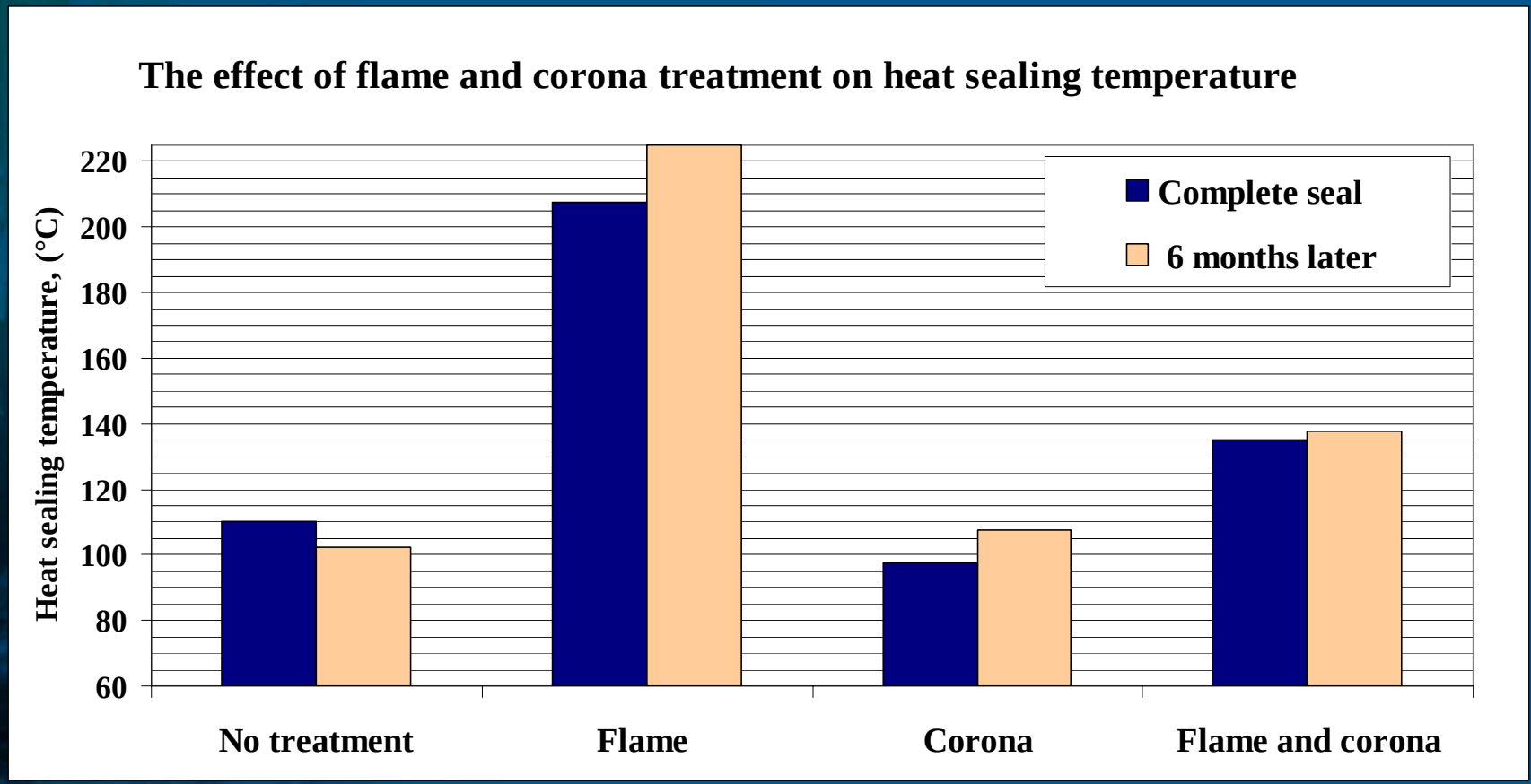
Surface energy



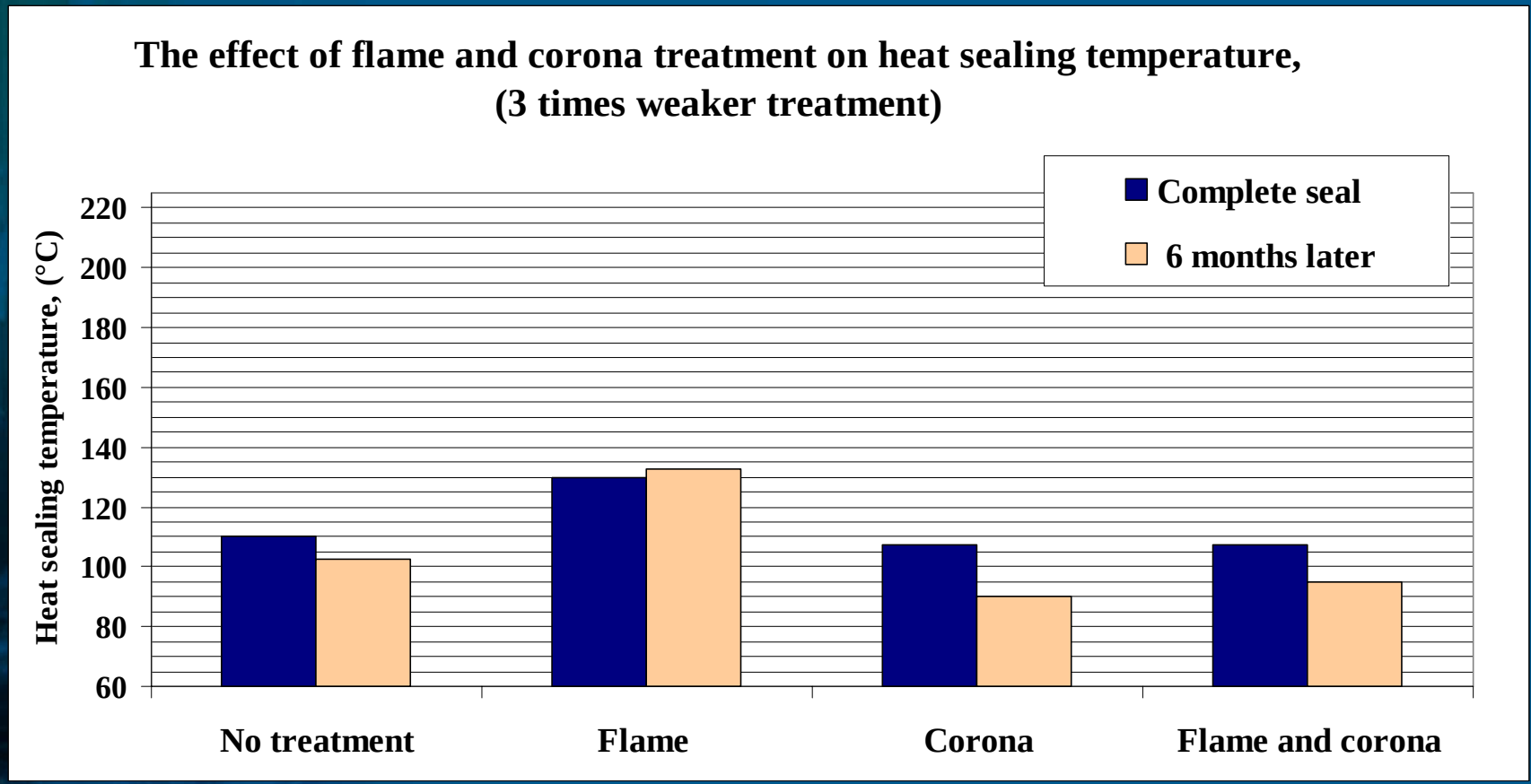
Surface energy

- The corona treatment is more effective than the flame treatment, but the co-effect of flame and corona is the most effective
- The decay of surface energy over time is slowest with flame treatment, also the co-treated test point retains surface energy better than the plain corona treated test point
- When the efficiency of treatment is decreased, the effect of corona treated and co-treated test points remains quite similar compared to more efficient treatment
- On the other hand, the flame treatment somewhat looses its long-lasting effect, when the efficiency of the treatment is reduced
- Order of the treatments is significant. If the surface is first treated with flame and later on with corona, the surface energy is much higher, but the decay over time is evident
- On the other hand, if corona treatment is the first and flame treatment the latter, the surface energy is clearly lower, although the decay is much slower

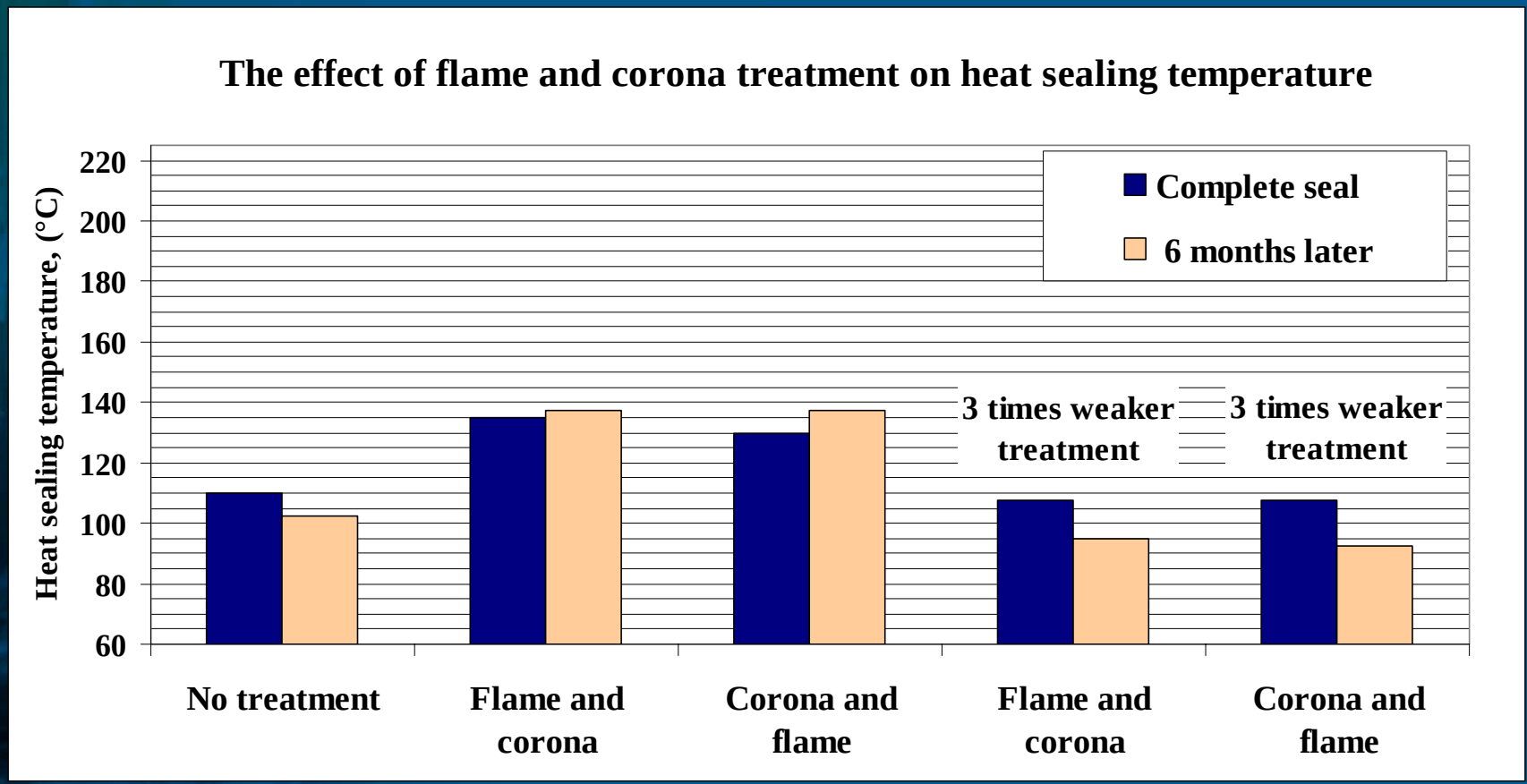
Heat sealability (heat sealing temperature)



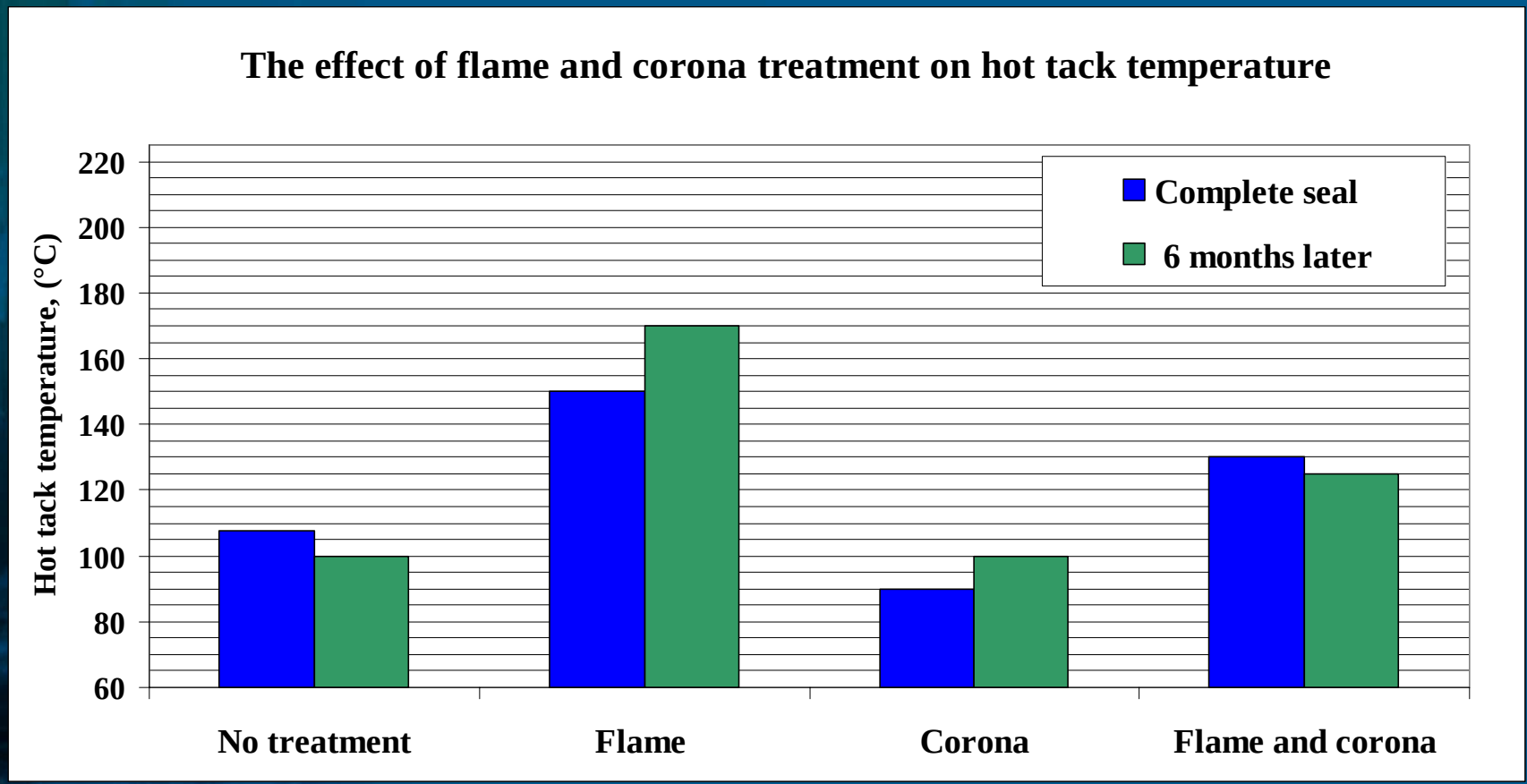
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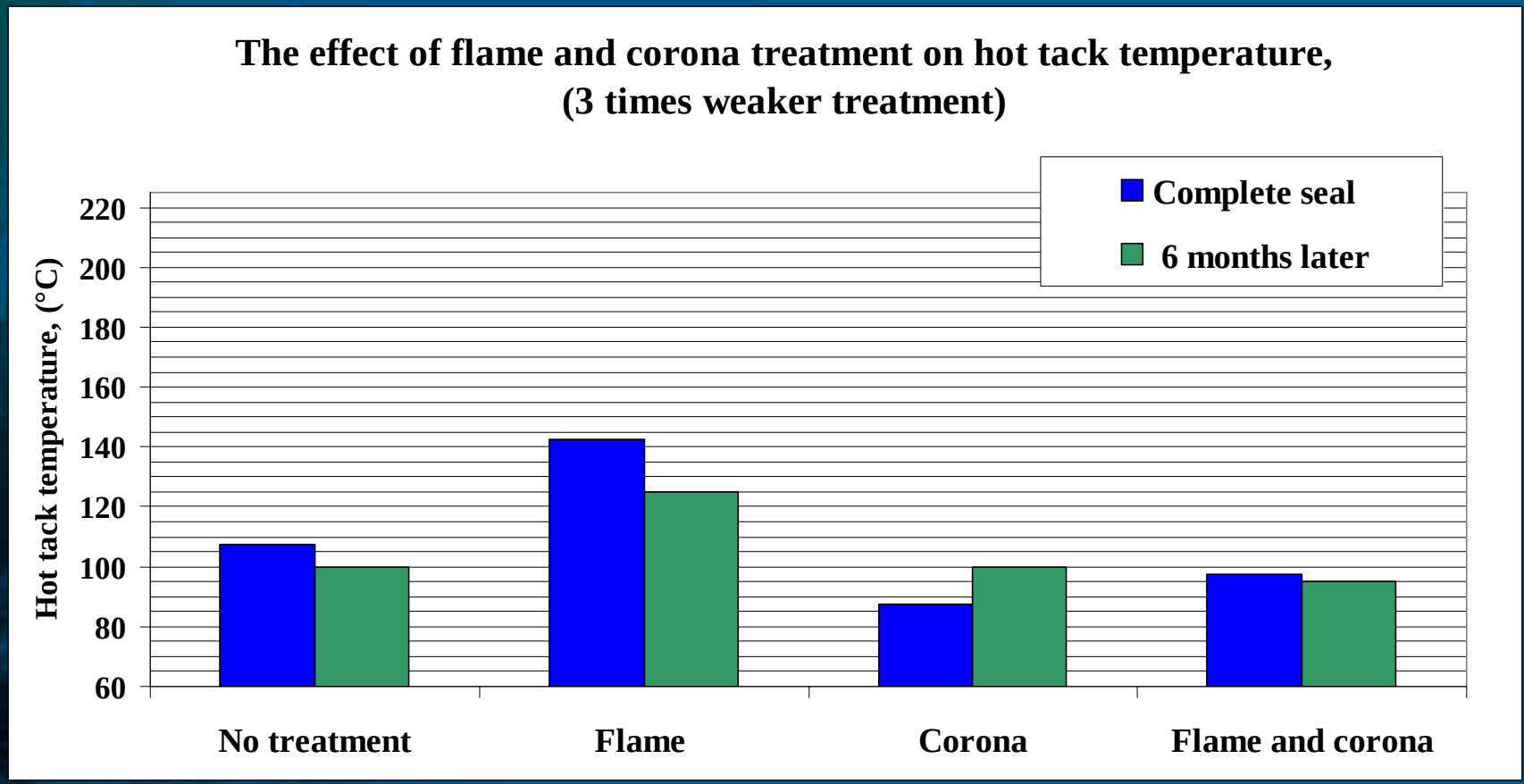
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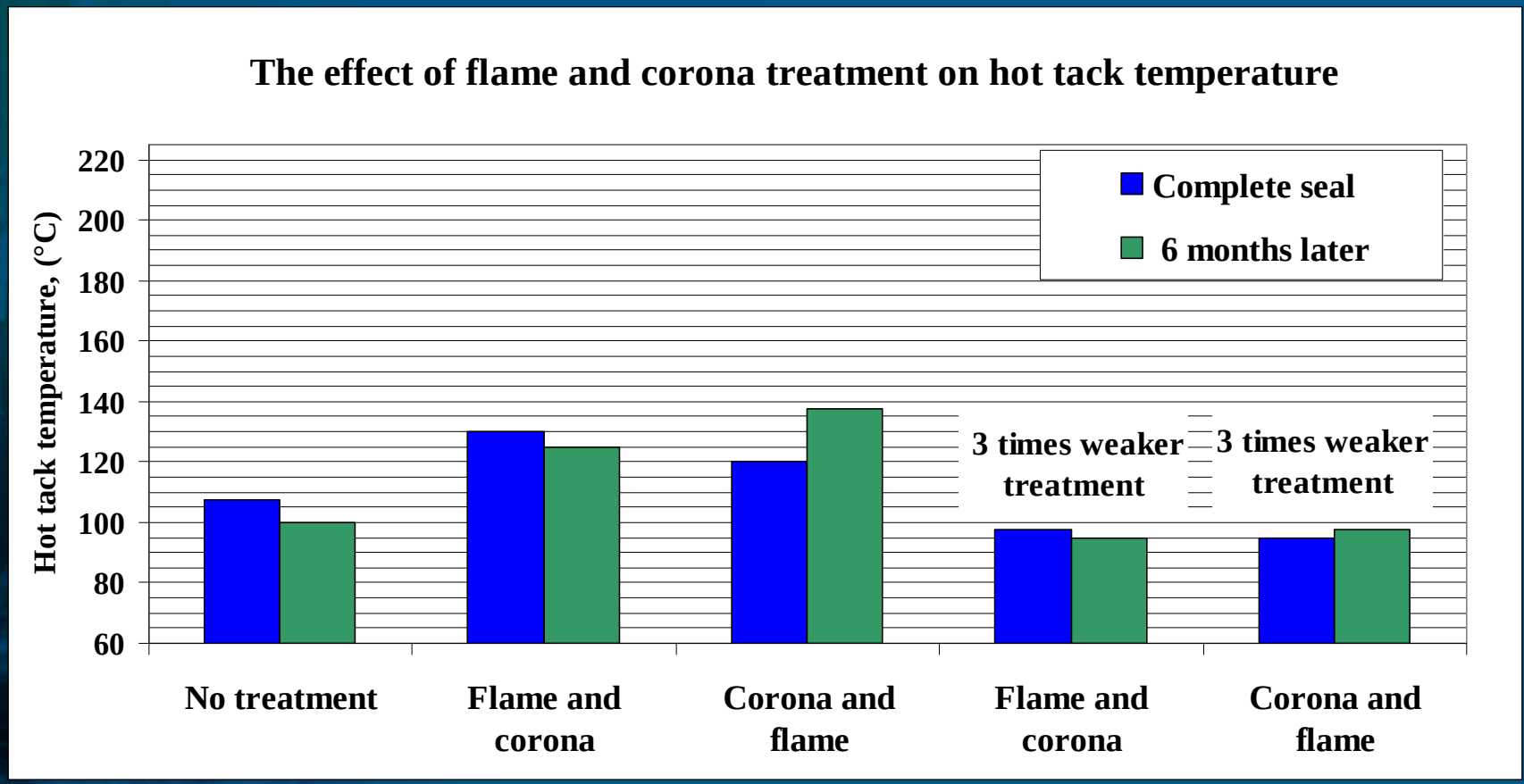
Heat sealability (hot tack temperature)



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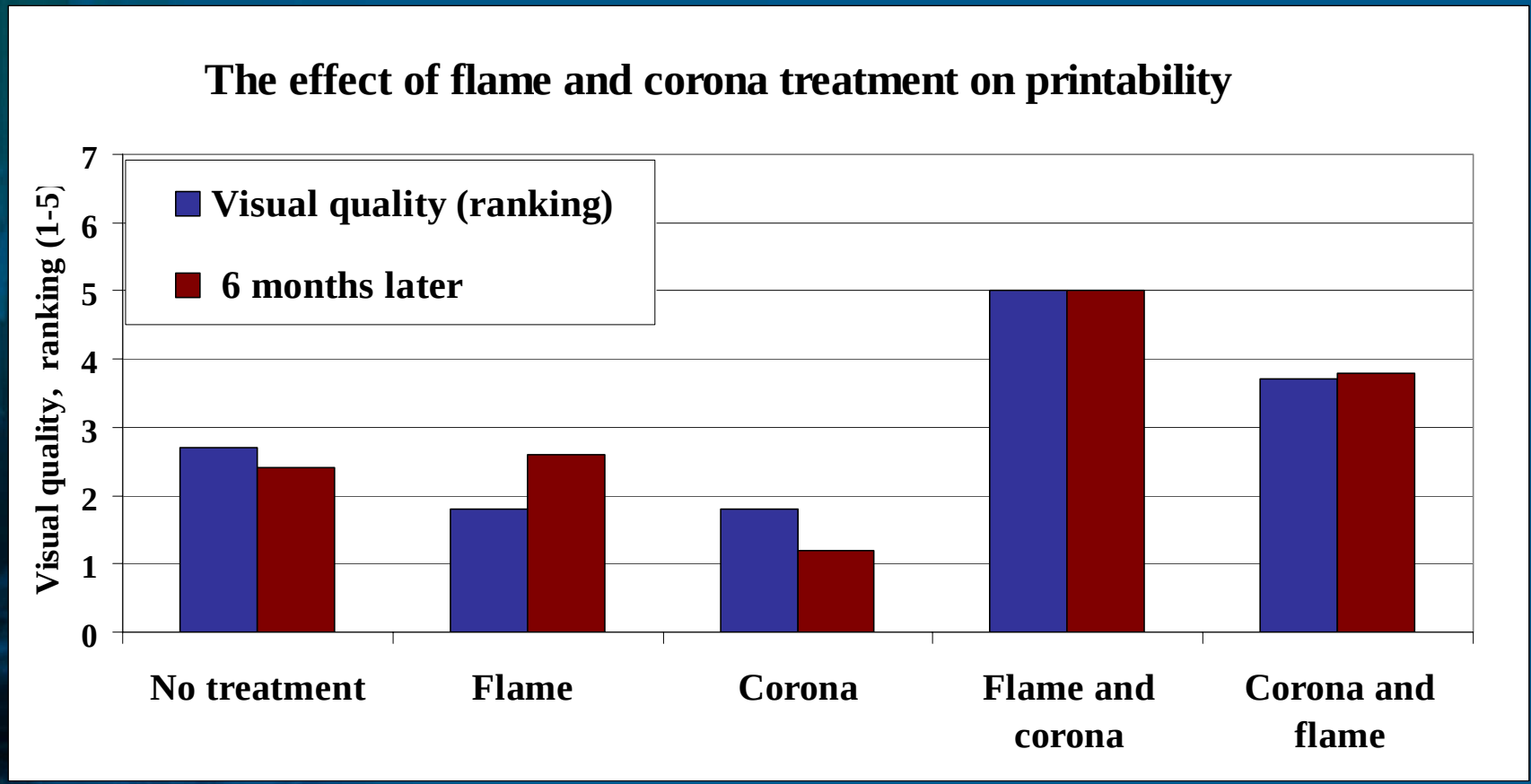
Heat sealability (hot tack temperature)



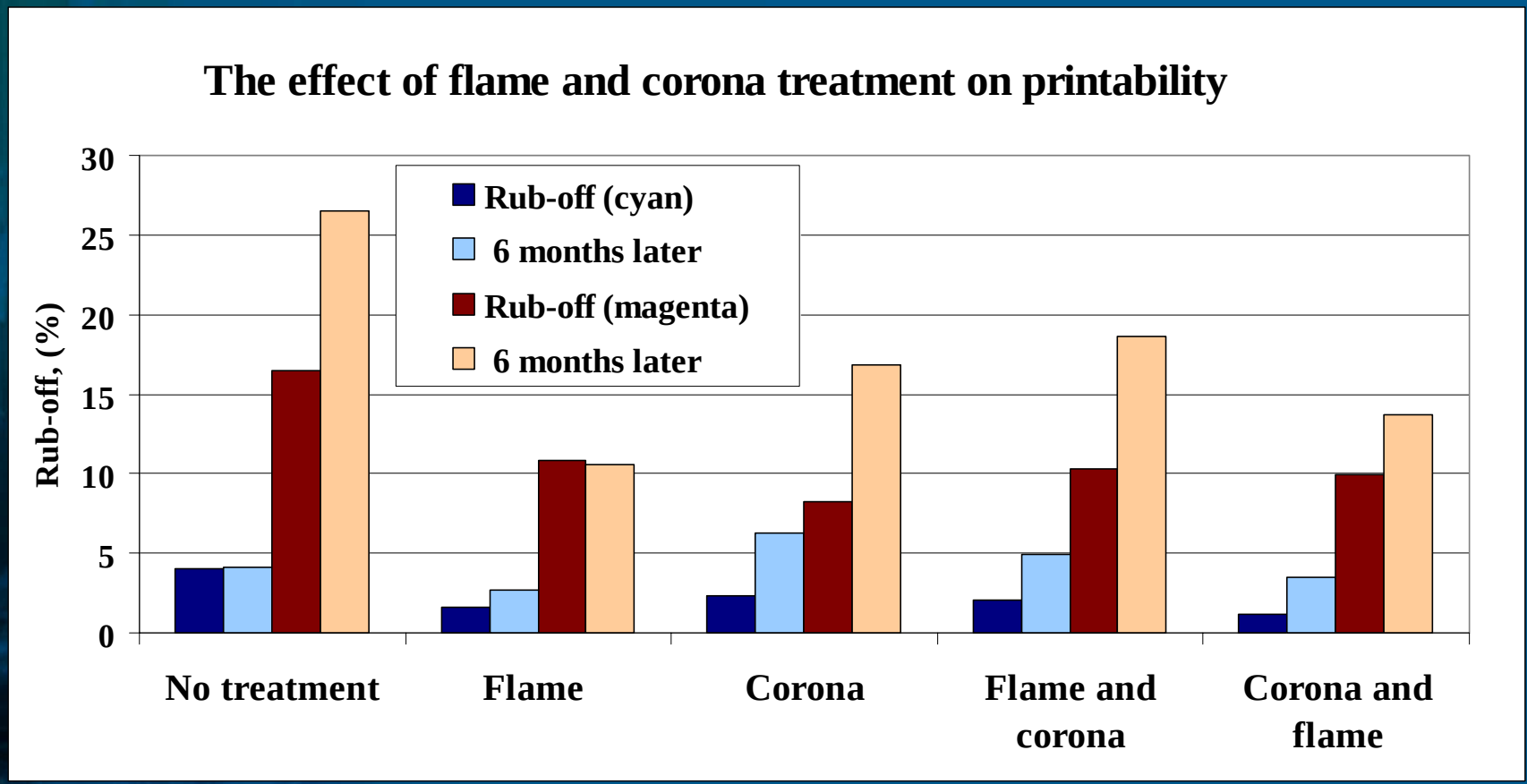
Heat sealability

- Corona treatment improves heat sealability and hot tack by decreasing the sealing temperatures a bit
- Flame treatment increases the sealing temperatures remarkably at high efficiency level. When the efficiency is decreased, the increase in sealing temperatures is only minor
- The co-effect increases the sealing temperatures slightly at high efficiency level, but not anymore at lower efficiency levels
- The treatment order has no significant effect on heat sealing temperatures

Printability



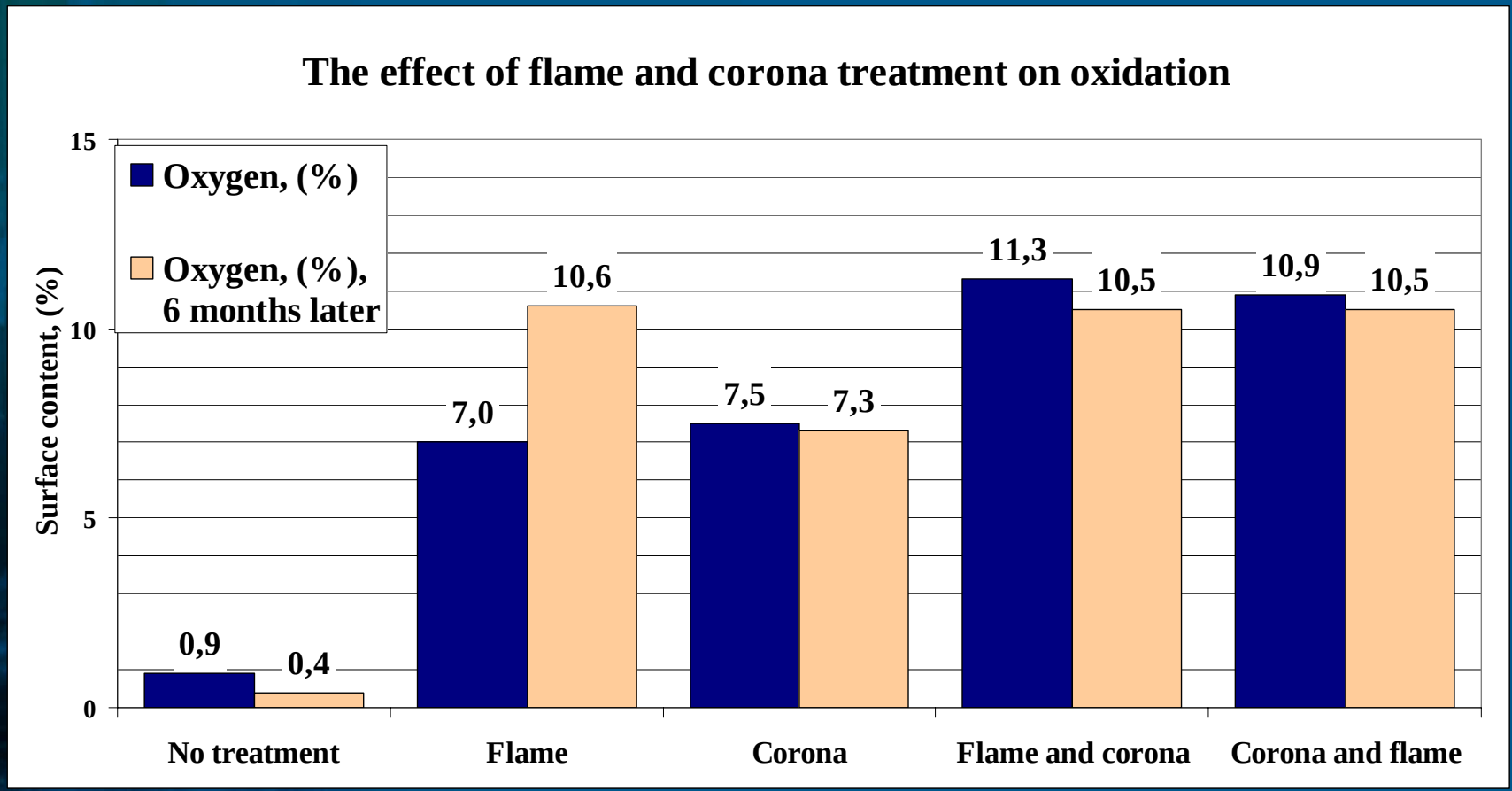
Printability



Printability

- Corona treated test point was ranked the best and the flame treated test point was the second
- When both treatments were used together, the visual quality was the poorest
- The corona treated test point has the lowest print mottle also by numerical measurement
- The flame and corona treated test point has the highest print mottle also numerically measured
- Surface treatments clearly increase the abrasion resistance of the printed images measured as rub-off values
- The flame treated sample maintains its properties best

Oxidation and surface compounds



Oxidation and surface compounds

	No treatment	Flame	Corona	Flame and corona	Corona and flame
C-C & C-H bonds, (%)	98,2	89,9	90,7	87,3	86,0
6 months later	97,8	88,6	90,9	87,8	88,0
C-OH & C-O-C bonds, (%)	1,7	7,3	5,7	7,4	7,7
6 months later	2,1	6,4	6,1	7,3	7,0
C=O & O-C-O bonds, (%)	0,1	2,8	3,6	5,3	6,3
6 months later	0,1	5,0	3,0	4,9	5,0
Carbonyl-index	0,23	0,45	0,46	0,50	0,53
6 months later	0,24	0,42	0,34	0,44	0,52

Oxidation and chemical composition

- The oxygen content on the surface of flame or corona treated surface after treatment is equal, whereas the oxygen content on the surface of co-treated test point is around 30% higher
- The oxygen content of the treated surfaces decreases a bit after six months excluding the flame treated test point, in which the oxygen content increases over 30% after six months of aging
- Flame treated test point has more C-OH & C-O-C bonds on the top surface, whereas corona treated test point has more C=O and O-C-O bonds on the top surface
- The amount of C-C, C-H, C-OH & C-O-C bonds and carbonyl-index of the flame treated test point decrease a bit after six months, whereas C=O and O-C-O bonds increase remarkably
- The amount of C-C, C-H, C-OH & C-O-C bonds of the corona treated test points slightly increases after six months, but the amount of C=O and O-C-O bonds and carbonyl-index decreases

Conclusions

- Surface energy
  - Surface treatments clearly increase surface energy of PE-LD coated paperboard by oxidizing its surface
  - The co-effect of flame and corona, i.e. both the treatments together, is the most effective
  - The decay of the treatment effect over time is slowest with flame treatment. However, flame treatment looses its long-lasting effect, when the efficiency of the treatment is reduced
  - Order of the treatments is significant
    - If the surface is first treated with flame and later on with corona, the surface energy is much higher, but the decay over time is evident
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Conclusions

- Heat sealability
  - Corona treatment improves heat sealability by decreasing the sealing temperatures a bit
  - Flame treatment increases the sealing temperatures remarkably at high efficiency level. When the efficiency is decreased, the increase in sealing temperatures is only minor
  - The co-effect increases the sealing temperatures slightly at high efficiency level, but not anymore at lower efficiency levels
- Printability
  - Corona treated test point was ranked the best and the flame treated test point was the second
  - When both treatments were used together, the visual quality was the poorest

Conclusions

- Oxidation and chemical composition
  - The total oxygen content and the amount of different carbon and oxygen bonds on the top surface of PE-LD coated paperboard after the treatments are definitely various
  - Especially interesting is that how the amount of certain compounds (C=O, O-C-O bonds and carbonyl-index) changes after six months of aging
  - This change, together with different migration rates of miscellaneous surface compounds, might explain the behaviour (surface energy, heat sealability and printability) of treated samples over time
- The next steps
  - To examine the effects of flame, corona and plasma treatment on the surfaces of various polymers

Acknowledgements

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