

# THE EFFECT OF BENTONITE MICROPARTICLES ON THE REDEPOSITION OF SOLID IMPURITIES DURING WASHING OF COTTON FABRIC WITH MIXTURES OF ECOLOGICAL SURFACTANTS

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# INTRODUCTION

## Fabric softeners

(organic products added to the last rinse during washing of cotton fabrics)

**Fabric properties preferred by users.**

- Greater softness to the touch providing items that are softer, smooter, more pleasant with
- Enhanced flexibility
- Compressibility
- Elastic recovery.

**Organic softeners have disadvantages when used with fabrics.**

- Lack of biodegradability
- Increased hydrophobicity of the cotton fabric (loss of water absorption)
- Reduction of the confort of the garment or loss of performance by towel fabrics.

# INTRODUCTION

Natural products, such as

**SODIUM BENTONITE,**

was added to the detergent formulations to produce smoothing effect while washing, to obtain what is known as “**SOFTERGENT EFFECT**”.

## ADVANTAGES:

- Ecological natural product
- Softening during washing
- Lower cost
- Compatibility with all the other ingredients of modern detergent.
- It is reasonable to expect that dirt will not be redeposited.
- Reduce the deposition of zeolites on fabric.

# ABSTRACT

The subject of this work is to look at the influence of sodium **bentonite** along with the surfactants in ecological detergent.

For that purpose, **sodium bentonite** was added to the detergent formulations with two types of particle size, without surface treatment and **with** and **without ammonium silicone softener** treatment for showing this effect on their behaviour.

# ABSTRACT

The surfactants used were an anionic surfactant, namely **SDBS** (LAS), and two non-ionic surfactants, namely **APG (Alkyl Polyglucoside)** and **AE (fatty alcohol ethoxylate with 7 m.E.O )**, both separately and in mixtures of the anionic and non-ionic surfactants in different proportions, in order to determine their influence on redeposition of solid impurities during washing .

- **Redeposition behaviour** of the cotton fabric
- The **smoothness of cotton** fabrics produced by the bentonites microparticles after washing was evaluated **by handle**, and related with the inorganic ash content of the fabric.
- Likewise, the **electrical double layer** of the bentonites in the presence of surfactants was evaluated

## MATERIALS

### Fabrics.

- a) **Unsoiled cotton** fabric (Weave Style 400 of Testfabrics), without optical brightner for the deposition of solid impurities during washing.
- b) **100 % terry towel cotton** fabric for the determinations of the handle and ash contain after washing (without optical brighter was used).

# BENTONITES

## Sodium bentonites

-Sodium bentonite with the trade name **Big Horn CH 325** from Wyo-Ben Inc., Billings, Montana, USA, with a specific surface area of  $82 \text{ m}^2/\text{g}^{-1}$  and a particle size of 325 mesh (**47  $\mu$** )  $75\% \pm 4\%$ . Specific gravity :  $2,55 \pm 0,1$

-Sodium bentonite with the trade name **Big Horn CH 200** from Wyo-Ben Inc., Billings, Montana, USA, with a specific surface area of  $82 \text{ m}^2/\text{g}^{-1}$  and a particle size of 200 mesh (**75  $\mu$** )  $80\% \pm 4\%$ . Specific gravity :  $2,55 \pm 0,1$



# SURFACTANTS

## The surfactants used were:

a.) Anionic surfactant: sodium dodecylbenzenesulfonate (**SDBS**), reagent for analysis supplied by Sigma with purity of 80%.

## b.) Non-ionic surfactants:

Alkyl polyglucoside (**APG**) with 1,4 glucoside groups and an alkyl chain length of  $C_{12}$ - $C_{14}$ . The amount of active material was 50-53%. Average molecular weight was  $409.8 \text{ g.mol}^{-1}$ .

An fatty alcohol ethoxylated (**AE**) with mean 7 EO. with the trade name Synperonic A7, with 100% pure active ingredient.

# SOFTENING BENTONITES

**Polysiloxane with quaternary ammonium at the ends of the silicone chain provided by Hansa Textilchemie GmbH was used with the molecular weight of  $6,000 \text{ g.mol}^{-1}$  and 95% solid content, microemulsion with the suitable size of particle was prepared.**

**The application of softener on bentonite particles by exhaustion 8% by weight was used, at  $40^{\circ}\text{C}$  during 30 minutes.**

## SOLID IMPURITY

**Carbon black Raven 1040 was used, from Columbian, with a particle diameter of 29 nm and specific area of 85 m<sup>2</sup>.g<sup>-1</sup>.**

**For use in the washing baths it was used properly dispersed in isopropyl alcohol with the aid of a vibroshaker.**

## EQUIPMENTS USED

### Washing equipment

The Launder-Ometer from Atlas Instrument (USA).



### Spectrophotometer

The reflectance of fabrics was measured using a Color i7 spectrophotometer with iQC Standard colour software from X-Rite Incorporated (USA),





# EQUIPMENTS USED

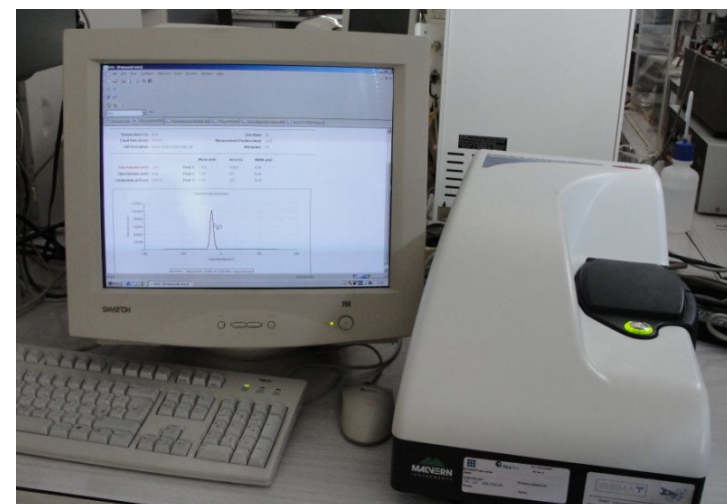
## ELECTRON MICROSCOPY

**A JOEL JSM-Series 5610 scanning electron microscope**

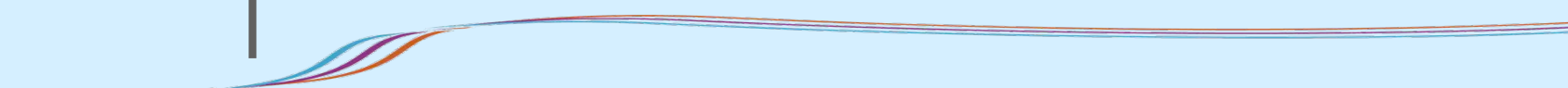


## Zeta potential measurements

**Zetasizer Nano ZS device from Malvern (UK).**



## Deposition washing impurities

- 
- Deposition test: According of ISO Standard 105/DAD 1 with Launder-Ometer equipment with 500 ml containers and cotton fabric specimen of 10x 4 cm.**
  - Solid impurity (carbon black) 10 mg dispersed in 2,5 ml of 2 -propanol**
  - The total concentration of surfactants being  $5 \cdot 10^{-3} \text{M}$ , in the molar proportions of 1:0 ; 0,8:0,2 ; 0,6:0,4 ; 0,4:0,6 ; 0,2:0,8 and 0:1.**
  - The bentonite tested was used at  $0.8 \text{ g.l}^{-1}$**
  - Bath volume: 150 ml with 10 stainless steel balls for agitation;**
  - The temperature set for each test was  $40^{\circ}\text{C}$**
  - Wash time: 30 minutes;**
  - De-ionised wash water.**

**Each deposition result was the average of the two identical test carried out.**

## Assessment of terry towel cotton fabric



**The specimens of washed terry towel cotton fabric for softness evaluation were washed with anionic (SDBS), non ionic (AE with 7 m EO) and mixtures SDBS with AE in the molar proportion 0.6:0.4 at a total concentration of  $5 \cdot 10^{-3}$  M in both cases and with  $2.4 \text{ g/l}^{-1}$  of bentonite.**

## Fabric softness tests

— The softness of the cotton fabric was tested by subjective **HANDLE** (sensations of softness and compressibility) by 5 observers, after washing

In order to ascertain the effect of the bentonites tested at a concentration of 2,4 g/L

- Original terry towel fabric as indicated as **O**
- Anionic surfactant (SDBS) indicated as **A**
- Non-ionic surfactant (APG,AE) as indicated as **B**
- Combined in the proportion 0,6:0,4 indicated as **C**

The following specimen pairs were evaluated:

**O with A, O with B, O with C, A with B, A with C and B with C**



## EVALUATION OF FABRIC CONTENTS AFTER WASHING



The **inorganic ash contents** before and after the test for deposition during washing was evaluated by Hobersal HD-230 **muffle furnace**.

**Fabric:** terry towel fabric

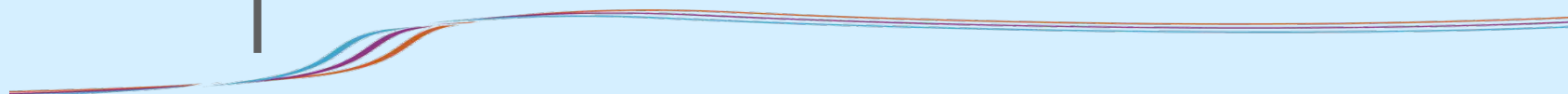
**Surfactants:** SDBS ,AE with 7m.E.O. and their mixture 0,6:0.4

**Surfactants concentration:**  $5 \cdot 10^{-3}$  M

**Concentration of bentonite:** 2,4 g.l<sup>-1</sup>

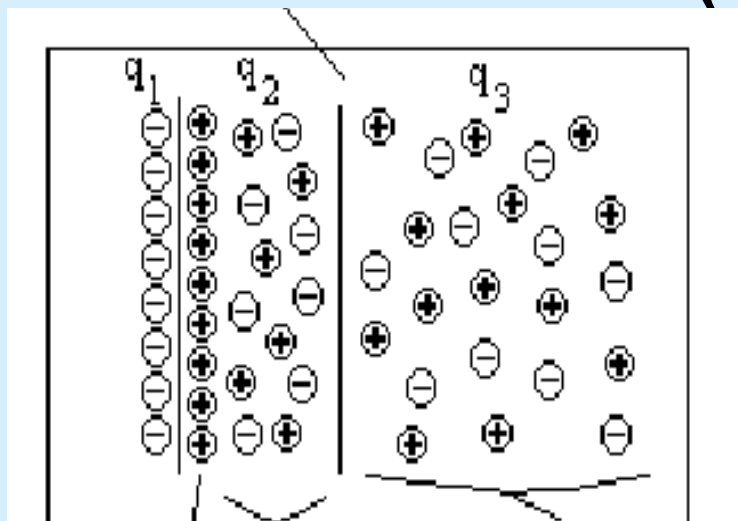
Results average of the three measurements were found.

## ZETA POTENTIAL



The zeta potentials of the bentonites BHCH 200 and BHCH 325 was found.

**Surfactants:** SDBS and the non-ionic surfactant APG and AE with 7m.E.O. and their 0,6:0,4 anionic:non-ionic mixtures ( total concentration  $5 \times 10^{-3}$  M)



**Electrolyte:**  $10^{-3}$  M Na Cl.

# Evaluation of results

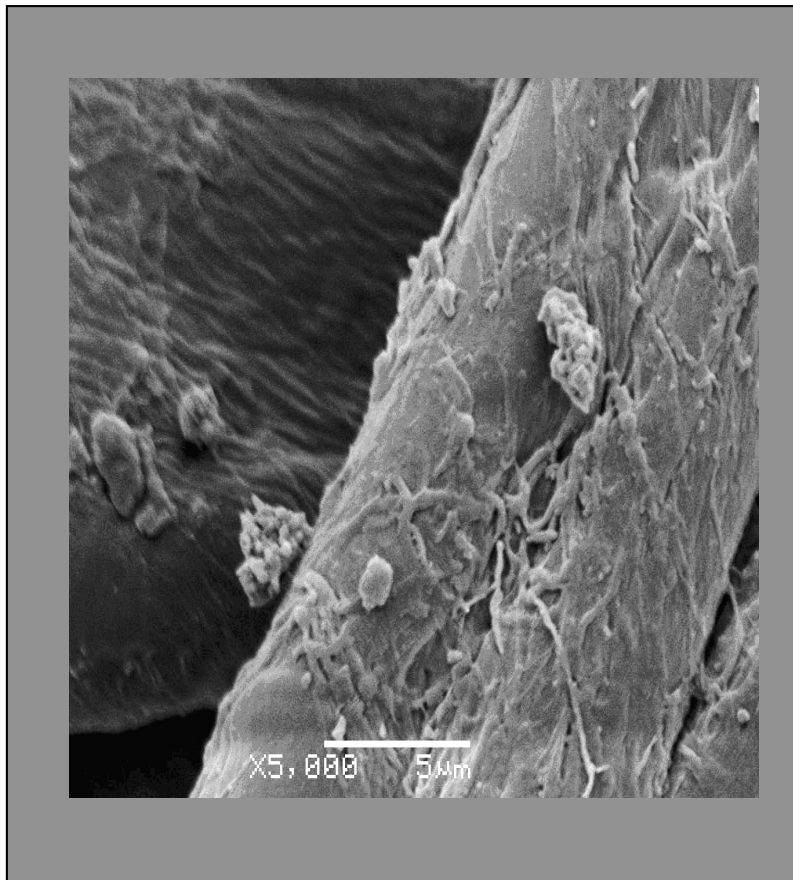
## Assessment of the degree of soiling

$$\Delta C = \{ (X_S - X_P)^2 + (Y_S - Y_P)^2 + (Z_S - Z_P)^2 \}^{1/2}$$

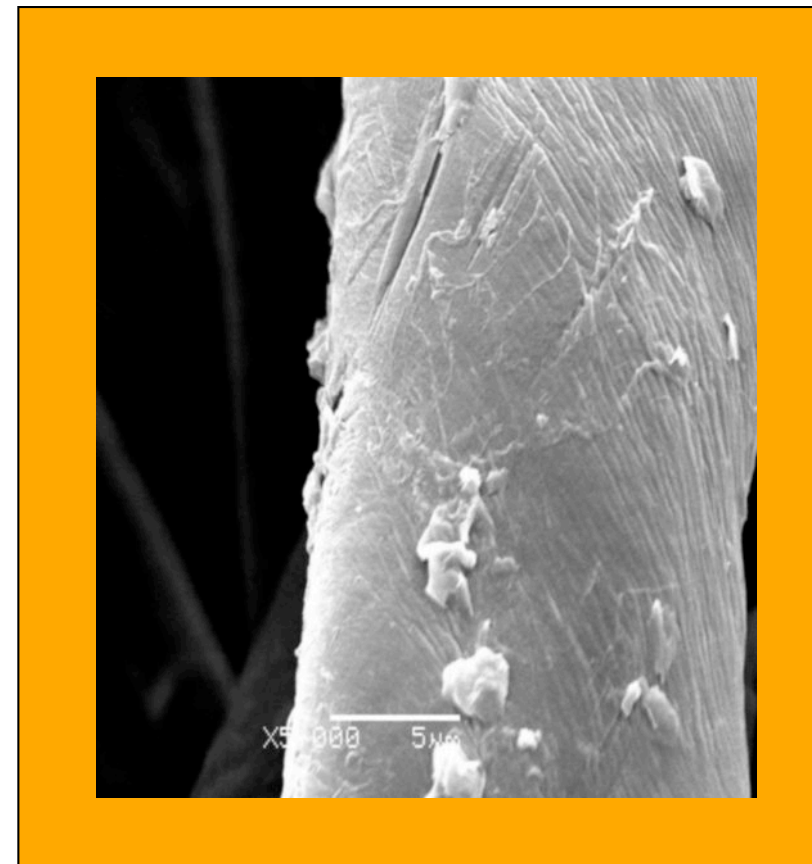
where  $X_P$ ,  $Y_P$  and  $Z_P$  are the **tristimulus values** of the white sample before the washing cycle and  $X_S$ ,  $Y_S$  and  $Z_S$  the tristimulus values of the sample **after the deposition or soiling test**.

(These values are the average of four reflectance readings).

# RESULTS AND DISCUSSION



**CHBH 325**



**CHBH 200**

Scanning electron microscope images bentonite (x 5000)  
on cotton fabric

# DEPOSITION OF SOLID IMPURITY

**Linear relationship between the degree of soiling and the amount of carbon black deposited on fabrics**

$$Y = 73,927 x - 11,533 \quad \text{Corre. Coef. } 0,961$$

Y = degree of soiling      x = mg C.m<sup>-2</sup>

Anionic (SDBS) : non-ionic  
5X10<sup>-3</sup>M

(APG) GLUCOPON 600

(AE) SYNPERONIC A-7

Bentonites with and without  
softener ammonium silicone  
0,8 g.l<sup>-1</sup>

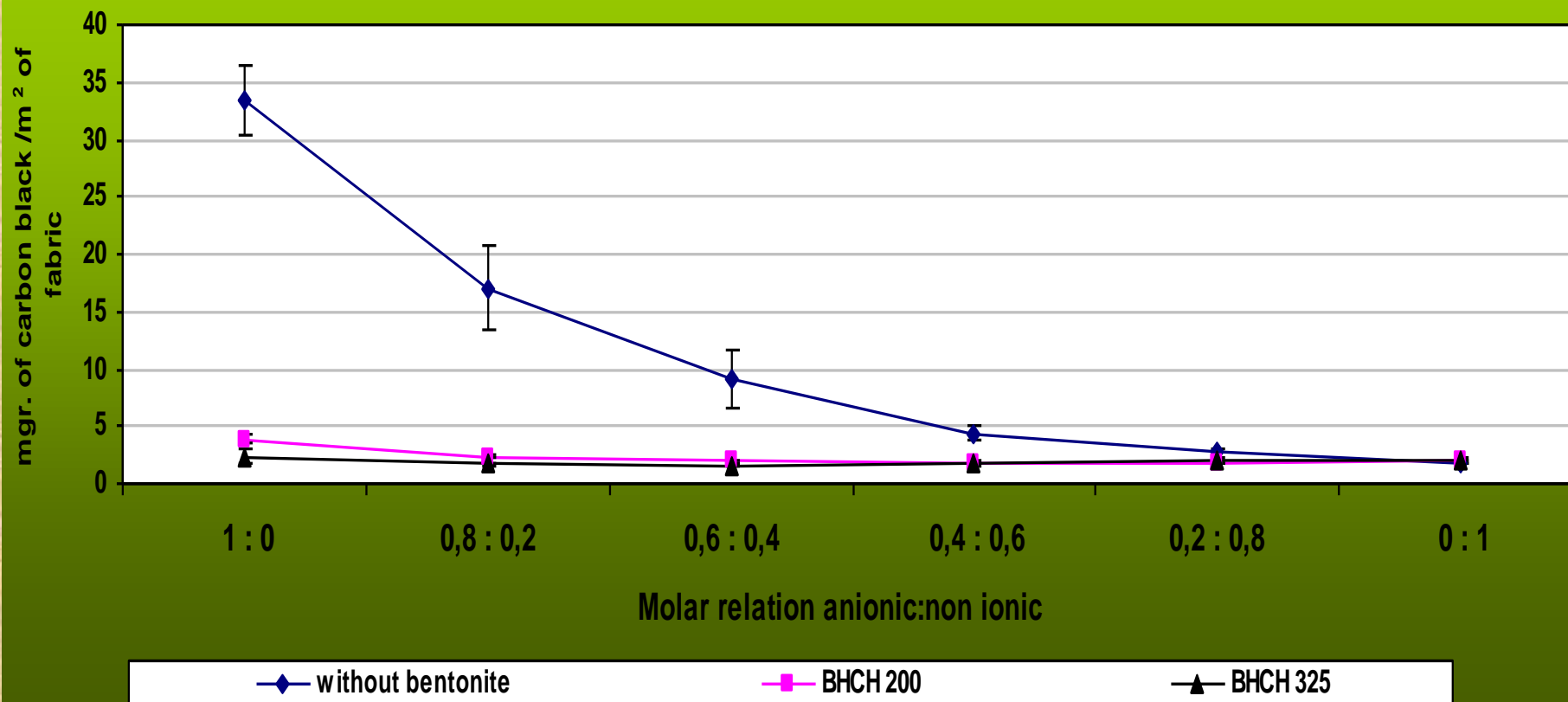
BHCH 200 (75 μ)

BHCH 325 (45 μ)



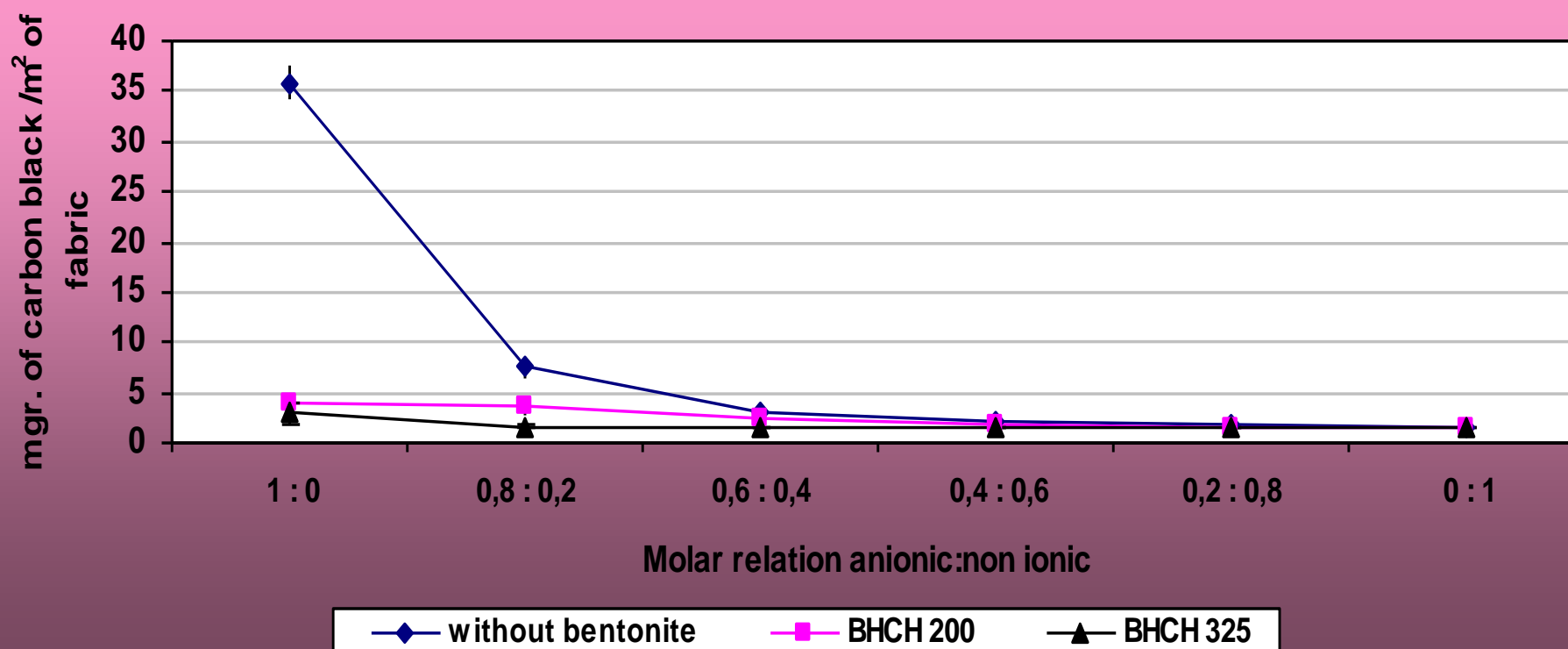
Amount of **carbon black deposited** at 40°C at the total surfactant concentration of  $5 \cdot 10^{-3}$  M with **anionic SDBS** and **non-ionic APG** (Glucopon 600) in different molar proportions anionic:non-ionic surfactants and **bentonites** (BHCH 200 and BHCH 325) .

### SDBS:Glucopon600

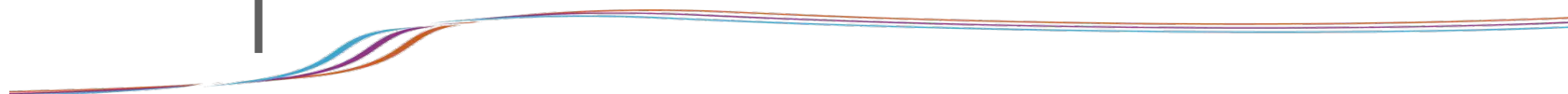


Amount of **carbon black** deposited at 40°C at the total surfactant concentration of  $5 \cdot 10^{-3}$  M with **anionic SDBS** and **non-ionic AE** with **7 m.EO** in different molar proportions anionic:non-ionic surfactants and **bentonites** (BHCH 200 and BHCH 325) .

SDBS:synperonic A-7



## DEPOSITION OF CARBON BLACK



The figures showing the decrease in the values for redeposition of carbon black in the presence of the bentonites BHCH 200 and BHCH 325 for the anionic:non-ionic surfactant mixtures tested, in comparison with the behaviour without bentonites.

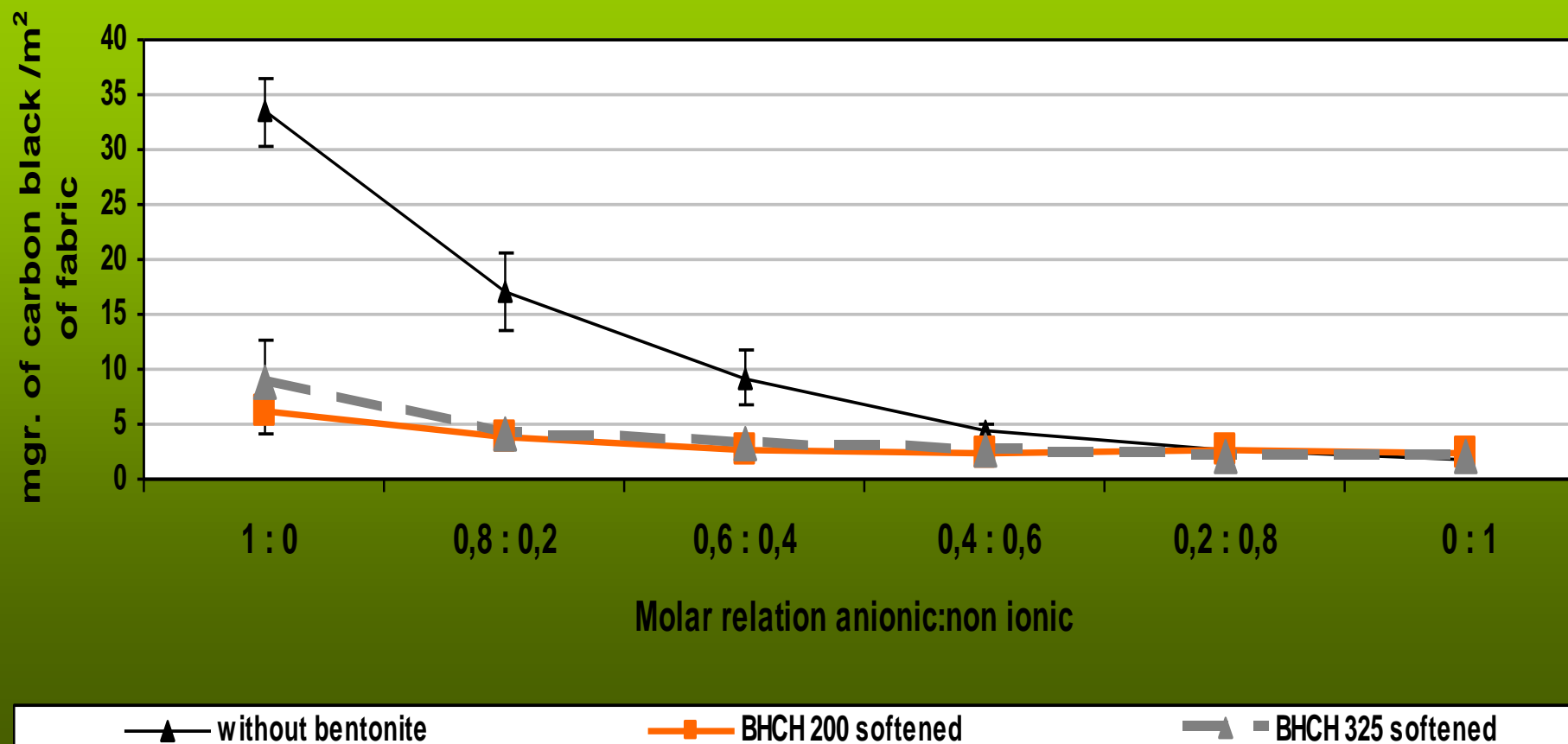
The greatest decrease in redeposition in the presence of the bentonite occurred with the surfactant SDBS and its mixtures with the non-ionic surfactant.

In the case of the non-ionic surfactants (APG and AE 7 m E.O.) the values remained at very similar levels. With no significant difference, since the initial values (without bentonites) were already very low.



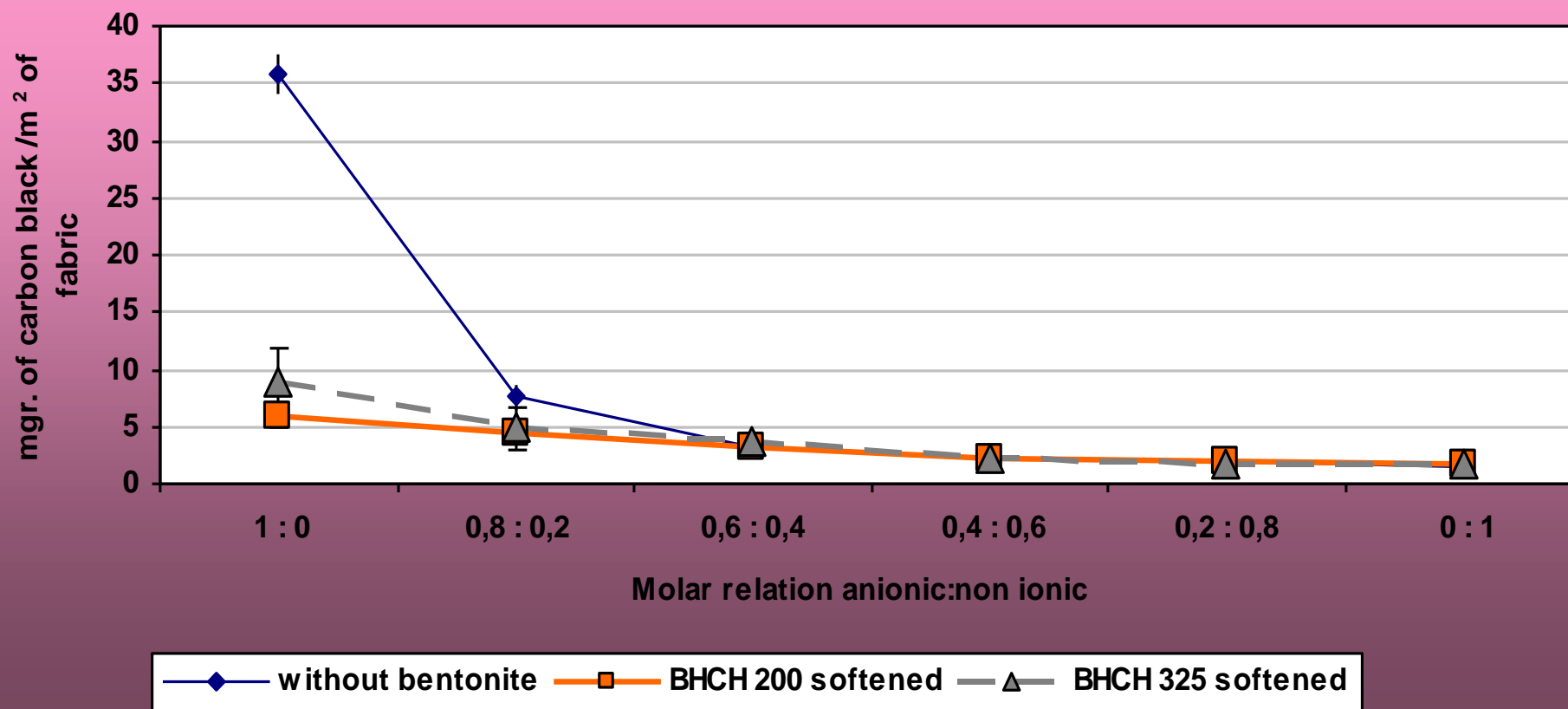
Amount of **carbon black** deposited at 40°C at the total concentration at  $5 \cdot 10^{-3}$  M with anionic **SDBS** and non-ionic **APG (Glucopon 600)** in different molar proportions anionic:non-ionic surfactants with and without bentonites (BHCH 200 and BHCH 325) **softened**

# SDBS:Glucopon600

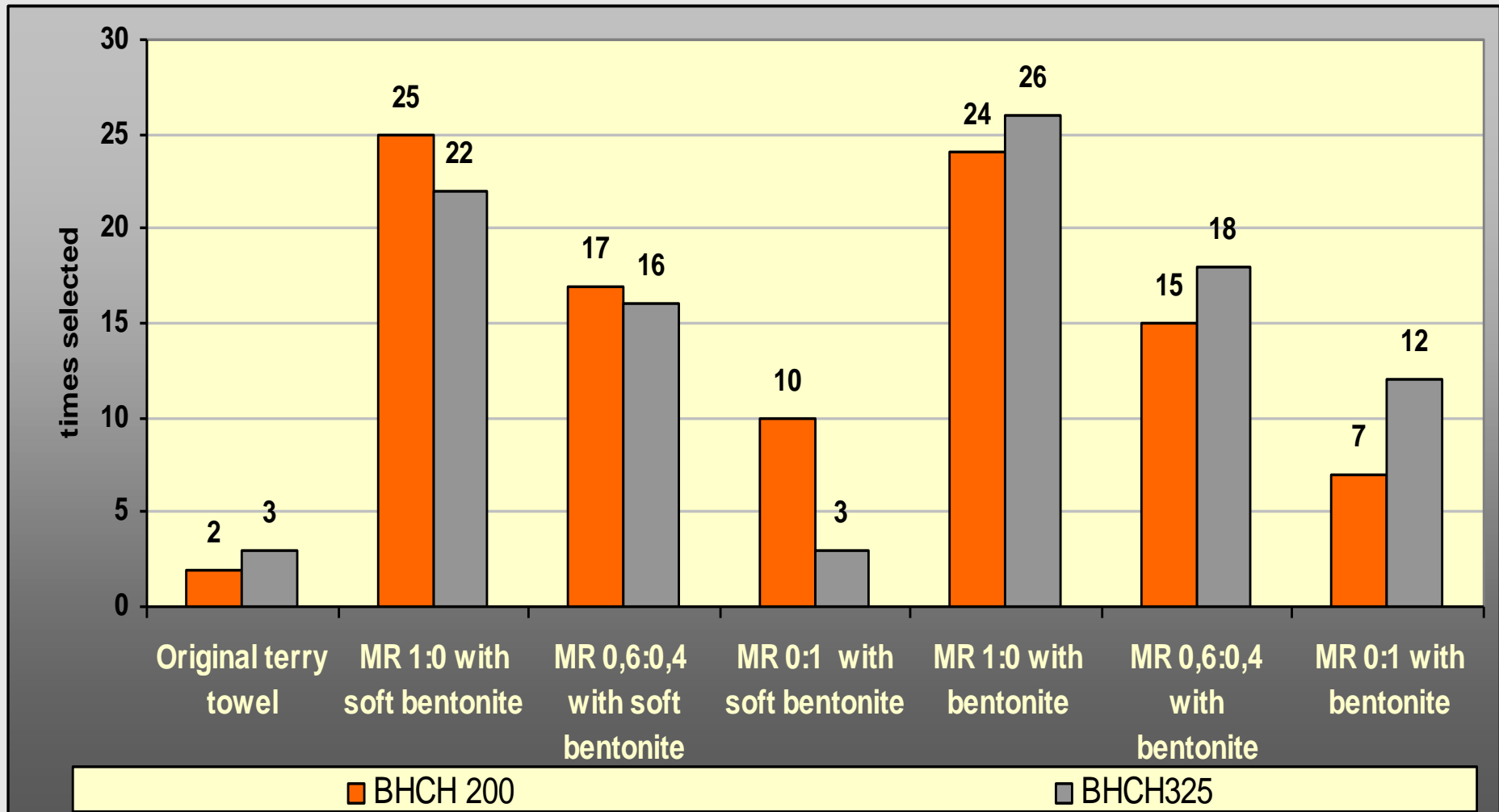


Amount of **carbon black deposited** at 40°C at the total concentration at  $5 \cdot 10^{-3}$  M with anionic **SDBS** and non-ionic **AE with 7m.EO (Synperonic A7)** in different molar proportions anionic:non-ionic surfactants with and without bentonites (BHCH 200 and BHCH 325) **softened**

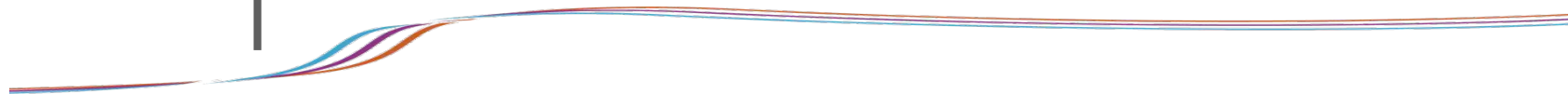
## SDBS:synperonic A-7



Evaluation of softness comparing pairs of samples, number of times chosen as softer, as a function of treatments applied to the cotton terry towel fabric. (1:0 - SDBS) (0,6:0,4- SDBS : AE) (0:1-AE)



## Softening effect of bentonite on cotton fabric



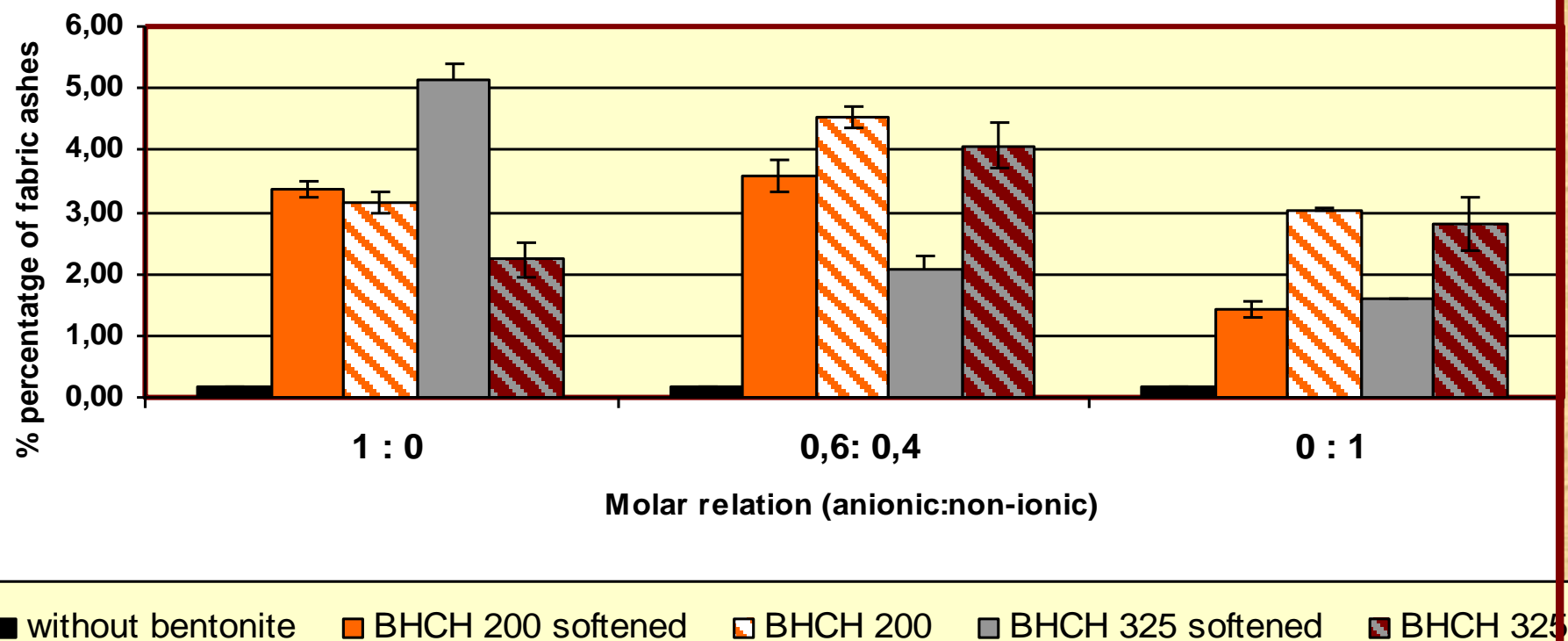
With both the softened and unsoftened bentonites, the higher values for softness corresponded to the fabric washed using the anionic surfactant SDBS and the lower values corresponded to the non-ionic surfactant AE with 7 m. EO. The 0.6:0.4 anionic:non-ionic mixture produced intermediate values.

In the evaluations of softness of the cotton fabric washed with the softened bentonite, the higher values were obtained for the bentonite BHCH 200 (larger particle size) in the three anionic:non-ionic proportions tested (1:0, 0.6:0.4 and 0:1).

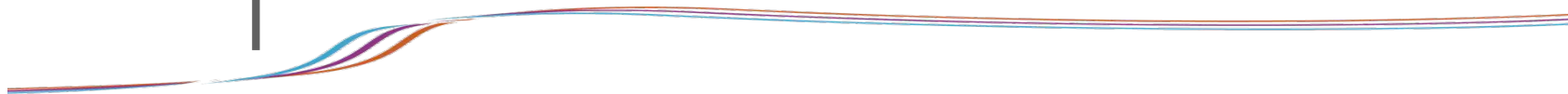
On the other hand, in the presence of the unsoftened bentonites, the best results for same proportions were obtained for the bentonite BHCH 325 (smaller particle size).

## ASH CONTENTS

Percentage of cotton fabric ash after washing with SDBS with AE with 7 m. EO (MR anionic:non-ionic) and BHCH 200 and BHCH 325 with and without softening



## Ash contents of the terry towel fabric washed with bentonites

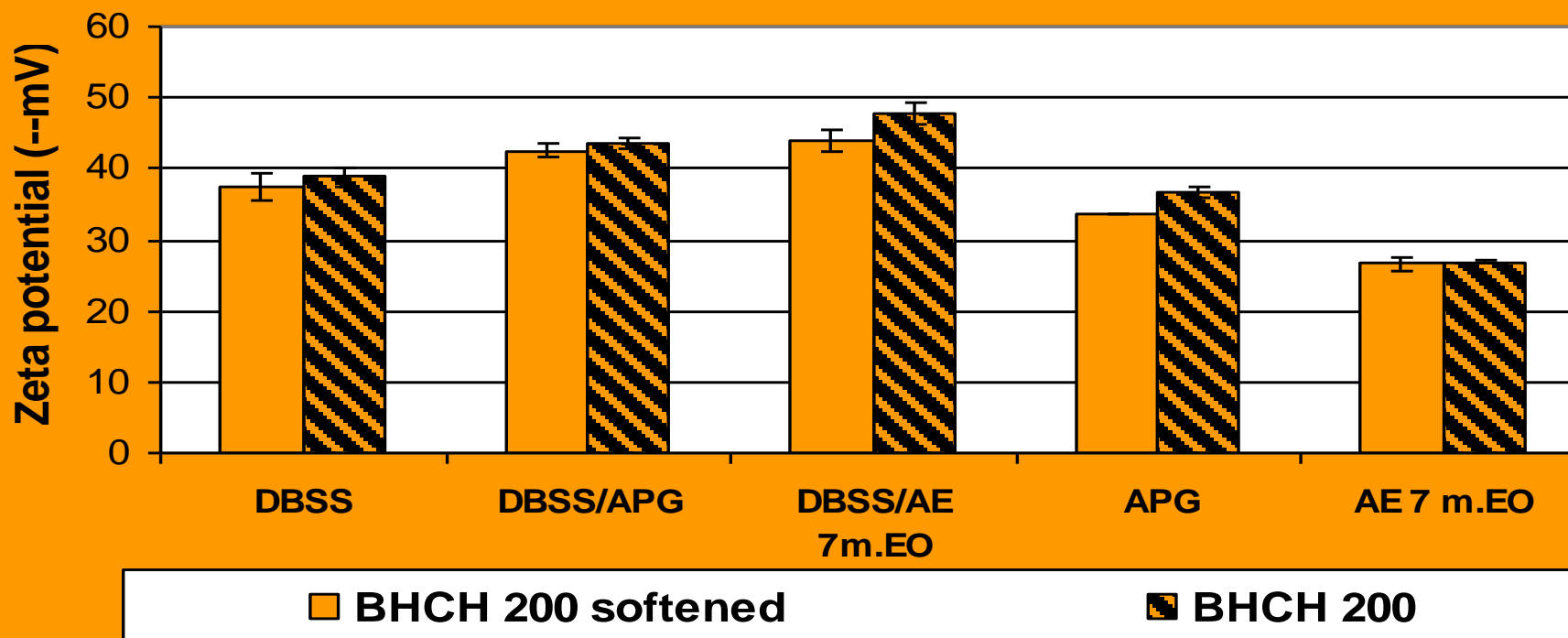


The surfactant SDBS in the presence of the tested bentonites gave the highest values for percentage of ash in comparison with the surfactant AE with 7 m. EO, which gave the lowest values.

The surfactant AE with 7 m. EO and its mixture with the SDBS (anionic:non-ionic 0.6:0.4) in the presence of the tested bentonites gave higher values for percentage of ash than the non-ionic surfactant used separately and, in general, somewhat higher values than the anionic surfactant used separately.

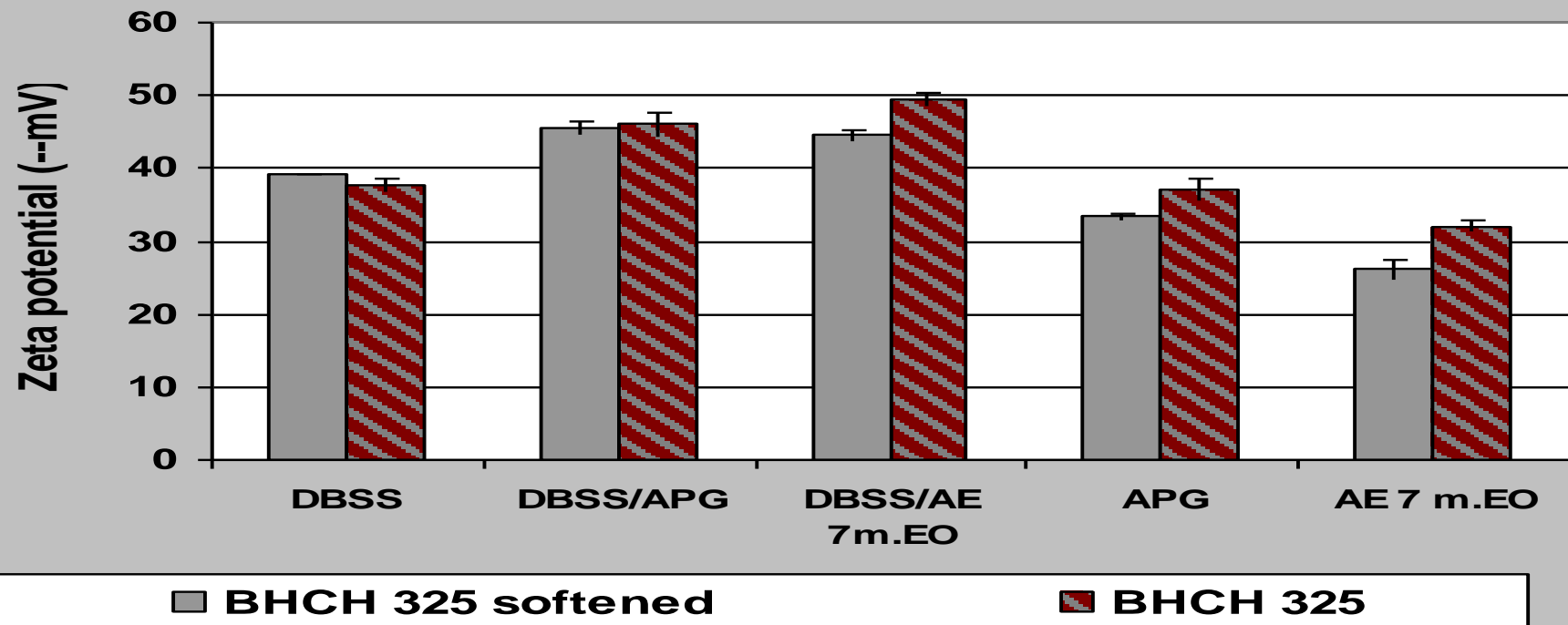
## Zeta potentials

Zeta potentials of bentonite BHCH 200 (75  $\mu$ ) at 40°C with and without softener and in the presence of SDBS, APG, AE 7 m. EO and in the anionic:non-ionic proportion 0.6:0.4 with  $10^{-3}$  M NaCl.



## Zeta potentials

Zeta potentials of bentonite BHCH 325 (45  $\mu$ ) at 40°C with and without softener and in the presence of SDBS, APG, AE 7 m. EO and in the anionic:non-ionic proportion 0.6:0.4 with  $10^{-3}$  M NaCl.





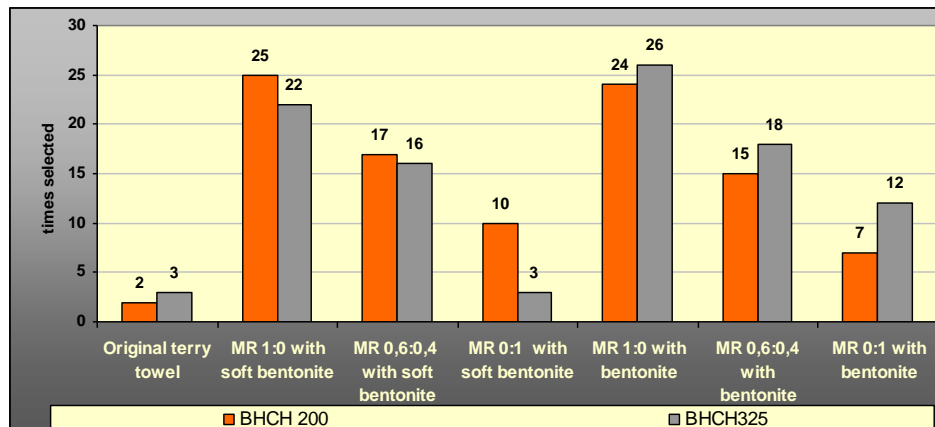
## Zeta potentials

Given those results, it is noted that the absolute value for zeta potential of the bentonites in the presence of SDBS was higher than the zeta potentials for the non-ionic surfactants APG and AE with 7 m. EO.

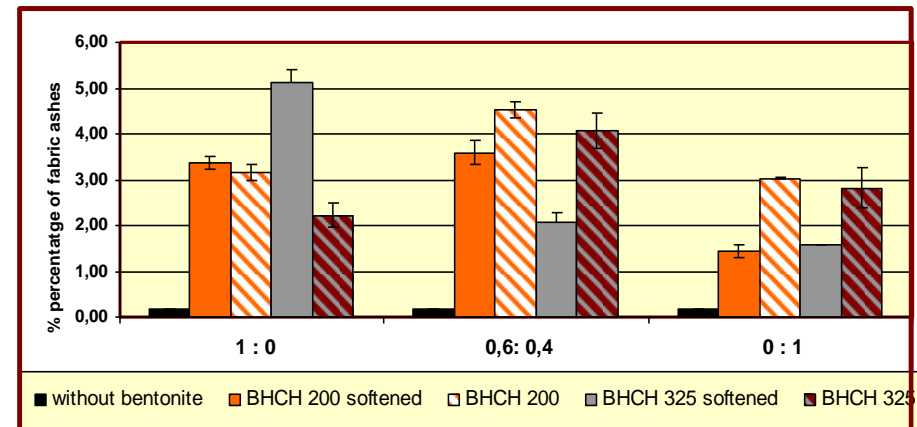
The zeta potentials for the 0.6:0.4 anionic:non-ionic surfactant mixture were higher than those obtained for the anionic and non-ionic surfactants separately.

It is noted that, in general, the zeta potentials for the softened bentonites were somewhat lower than those obtained for the same bentonites without softening, due to the cationic effect of the softener on those substrates.

## Relationship between softness of the cotton fabric and ash contents after washing



Softening effect



Ash content

Comparing the results shown in Figure (softness) with those shown in Figure (fabric ash content), it is noted that the higher the percentage of ash, implying a larger amount of softened bentonite, the greater the softness of the fabric after washing, as in the case of the SDBS and, to a lesser extent, in the case of the AE with 7 m. EO, used separately

# conclusions



- 1. All the bentonites tested, with and without softening treatment using ammoniumsilicone, provided a notable reduction of redeposition of carbon black during washing, mainly with the anionic surfactant and its mixtures with each of the non-ionic surfactants tested.**
- 2. Between the unsoftened bentonites, the one with the smaller particle size was slightly more effective in preventing redeposition, and between the softened bentonites, the one with the larger particle size was more effective. Those differences obtained between the bentonites with different particle sizes were not significant.**

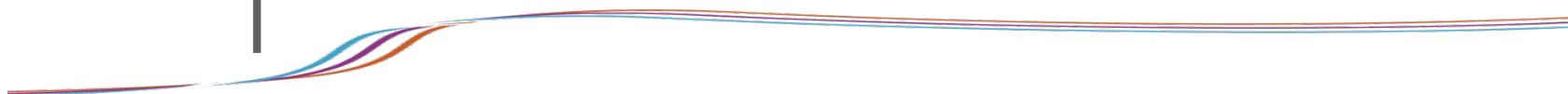
# conclusions

**3. The inorganic ash content obtained for the cotton fabric after washing was higher with the anionic surfactant SDBS than with the non-ionic surfactant AE with 7 m. EO. The mixture of the two surfactants gave results that were more similar to those obtained for the SDBS. The softened bentonites gave, in general, less ashes of the cotton fabric than unsoftened bentonites.**

**4. The higher the percentage of ash, which implies a greater amount of bentonite deposited on the fabric, the greater the softness of the fabric after washing, as in the case of de SDBS, and a lesser extent in the case of the AE with 7 m.E.O., both used separately.**

**5. The absolute values for the zeta potentials of the bentonites particles, both with and without softener, were higher with the anionic surfactant SDBS and lower with the non-ionic surfactant AE with 7 m.E.O., with slightly higher values for the bentonite with the smaller particle size. The mixture of the two surfactants gave slightly higher values than the anionic surfactant used alone.**

## Acknowledgements



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**Wyo-Ben Inc, Billings, Montana (USA) for supplying the Big Horn bentonites used.**

**Cognis Ibérica SL for supplying the APG surfactant,**

**Uniquema for supplying the AE surfactant,**





THANK YOU FOR YOUR  
ATTENTION