

Influence of base paper citrate and filler amount and of band diffusion on smoke deliveries, ASTM and FASE

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Objective:

Optimize the LIP papers design to cope with both 10/1/10 and ASTM requirements, keeping FASE low.

Parameters to be studied:

Base paper citrate, amount of CaCO_3 , and diffusion of the printed alginate bands.

Face centered cubic matrix:

Main effects, interactions and quadratic effects.

Targets for variables levels:

K Citrate (%) : 0,8 1,4 2,0

CaCO₃ (%) : 25 29 33

Band diffusion(cm/s) : 0,055 0,095 0,135

Blends:

2 types of blends used :

- American blend
- Virginia blend

Quality of the models

	US blend		Virginia blend	
	R ²	CoV	R ²	CoV
FASE	87	52	95	34
Tar	80	1,9	29	3.8
Nicotine	75	2,2	86	1.8
CO	98	1,1	81	2.7
CO/tar	85	1,7	67	1.8
Puff Nbr	85	2,3	74	2.1

Quality of the model:

ASTM results other than 100 %

US Blend	K Citrate (%)	Band Diffusion (cm/sec)	Filler (%)	ASTM (%)
	1.41	0.134	30.0	90
	2.02	0.095	31.9	95
	2.05	0.057	35.7	95
	2.05	0.138	35.7	95

Virginia Blend	K Citrate (%)	Band Diffusion (cm/sec)	Filler (%)	ASTM (%)
	2.02	0.095	31.9	90
	2.05	0.138	35.7	95

Tar, Nicotine, CO, FASE

Model reliable.

High variations on FASE , but r^2 are OK

Tar model is not good for Virginia cigarettes : 13 cigarettes out of 15 in 12,8-13,8 mg tar.

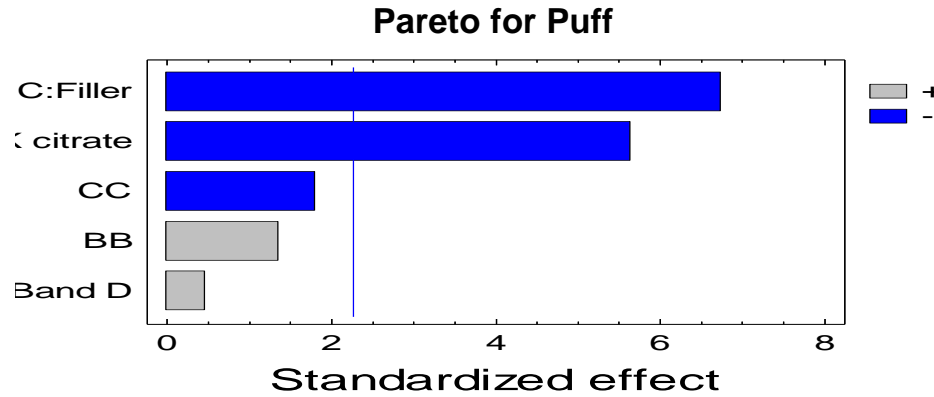
ASTM :

Model cannot be used as such for ASTM :

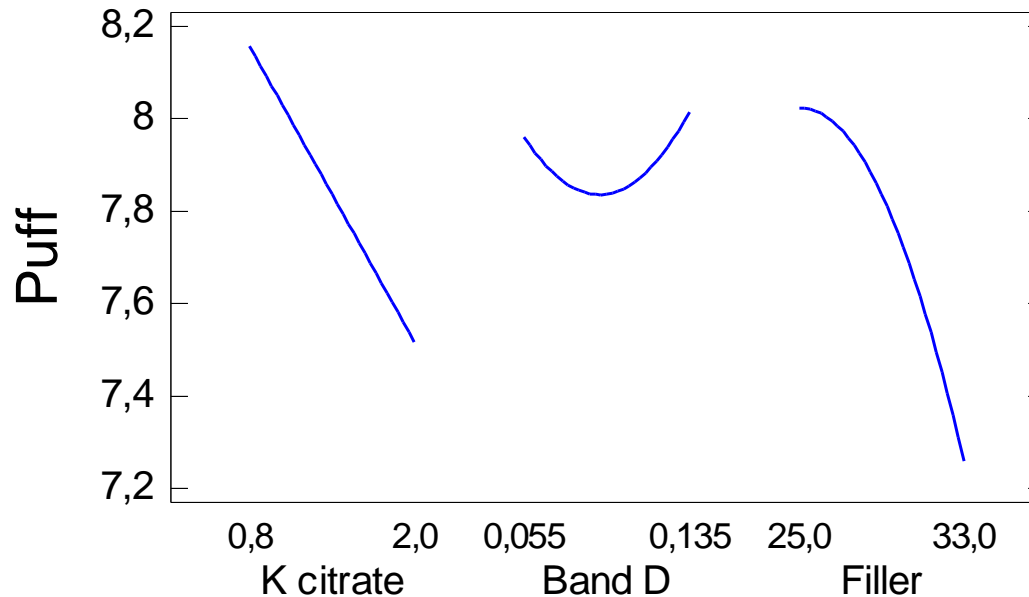
- 4 cigarettes below 100 % on US blend
- 2 cigarettes below 100 % on Virginia blend

For ASTM, US blends were re-tested using 5 layers of filter

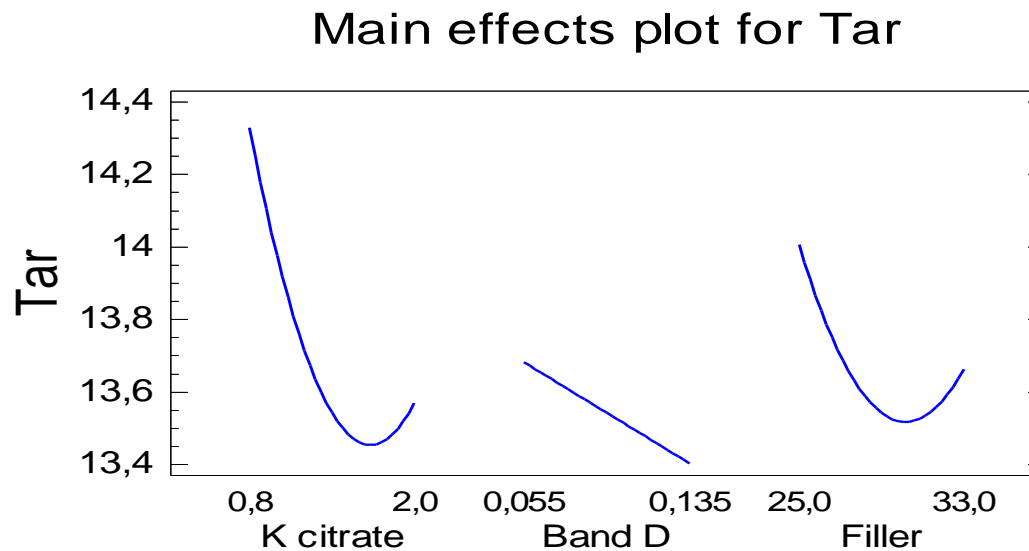
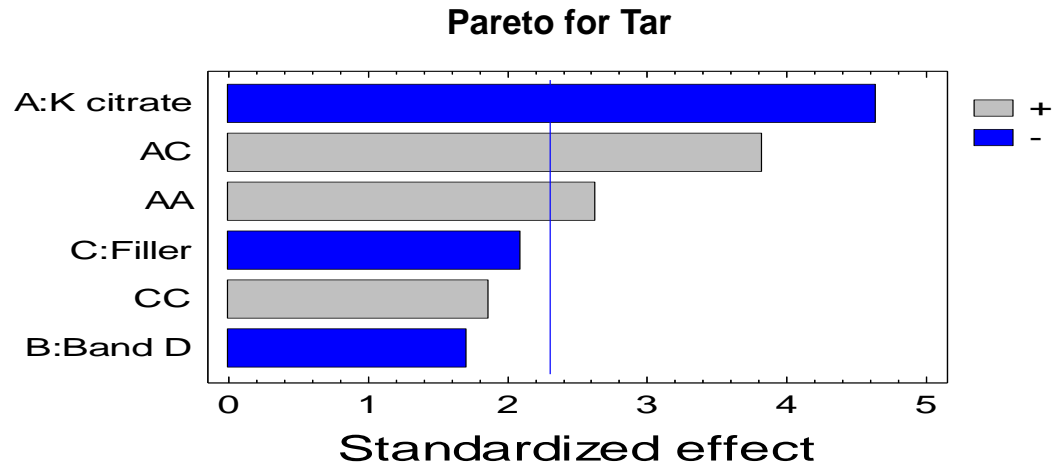
Results for puff number



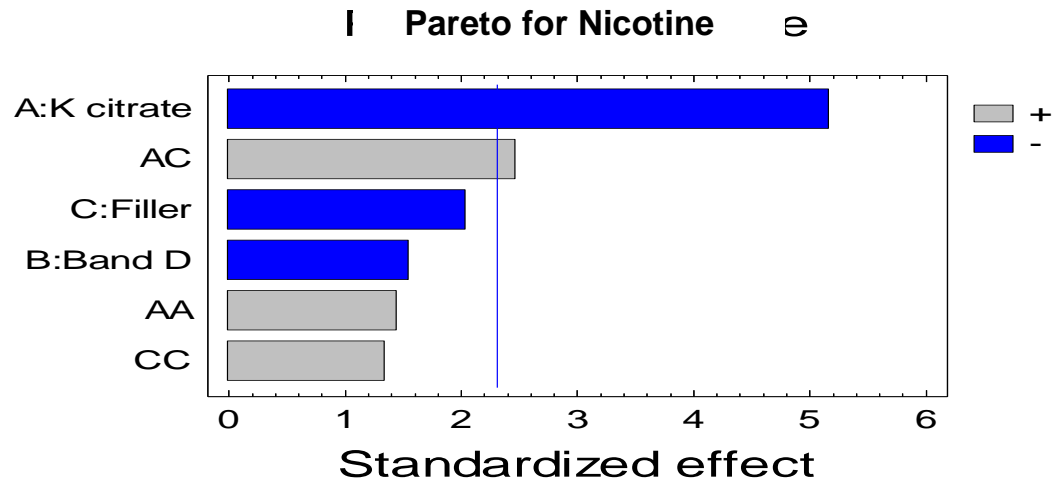
Main effects plot for Puff



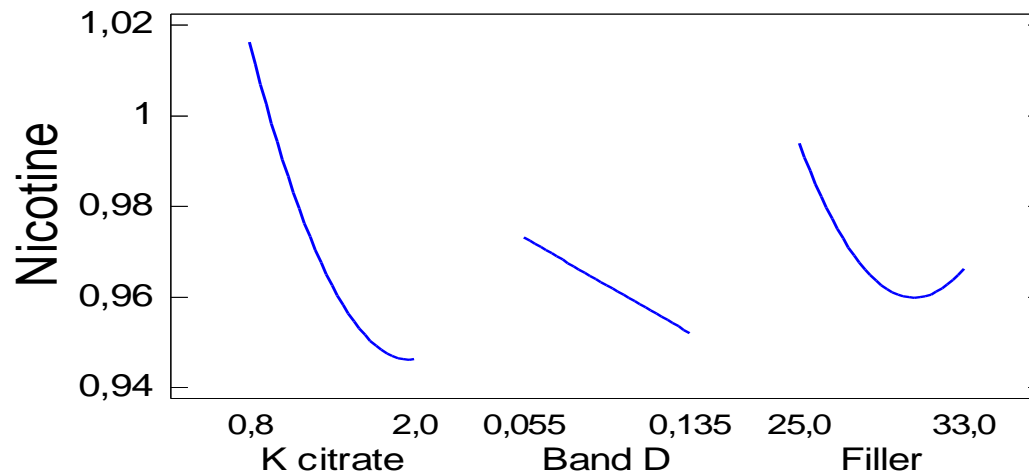
Results for tar



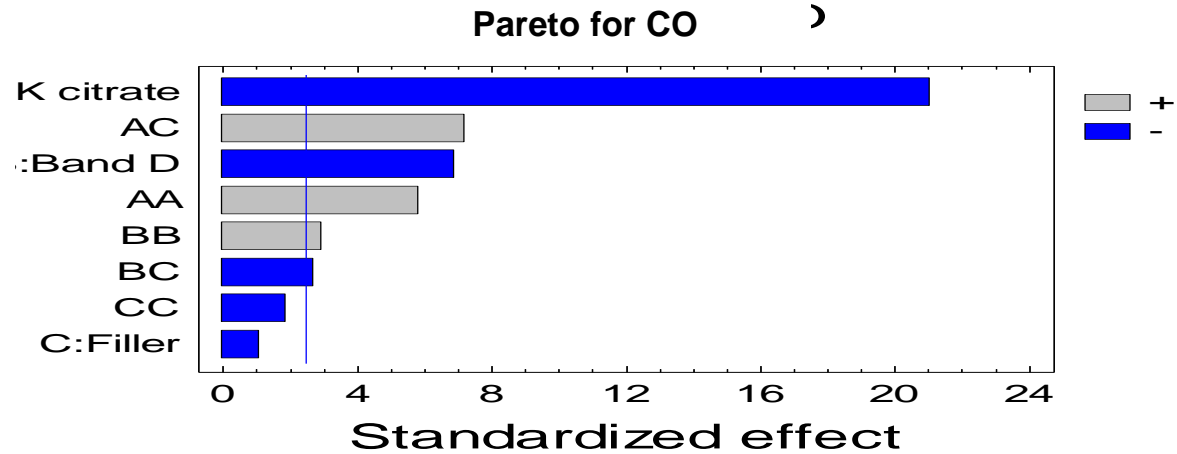
Results for nicotine



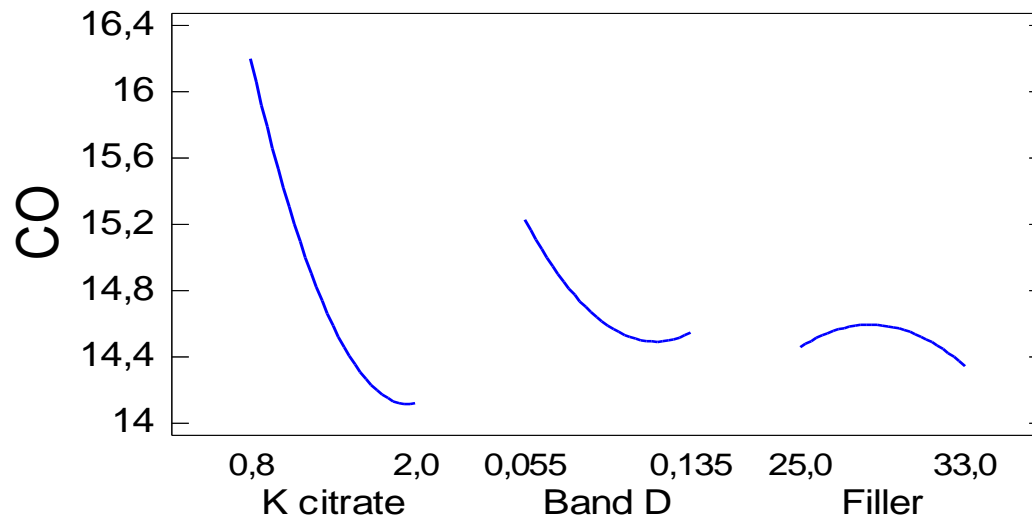
Main effects plot for Nicotine



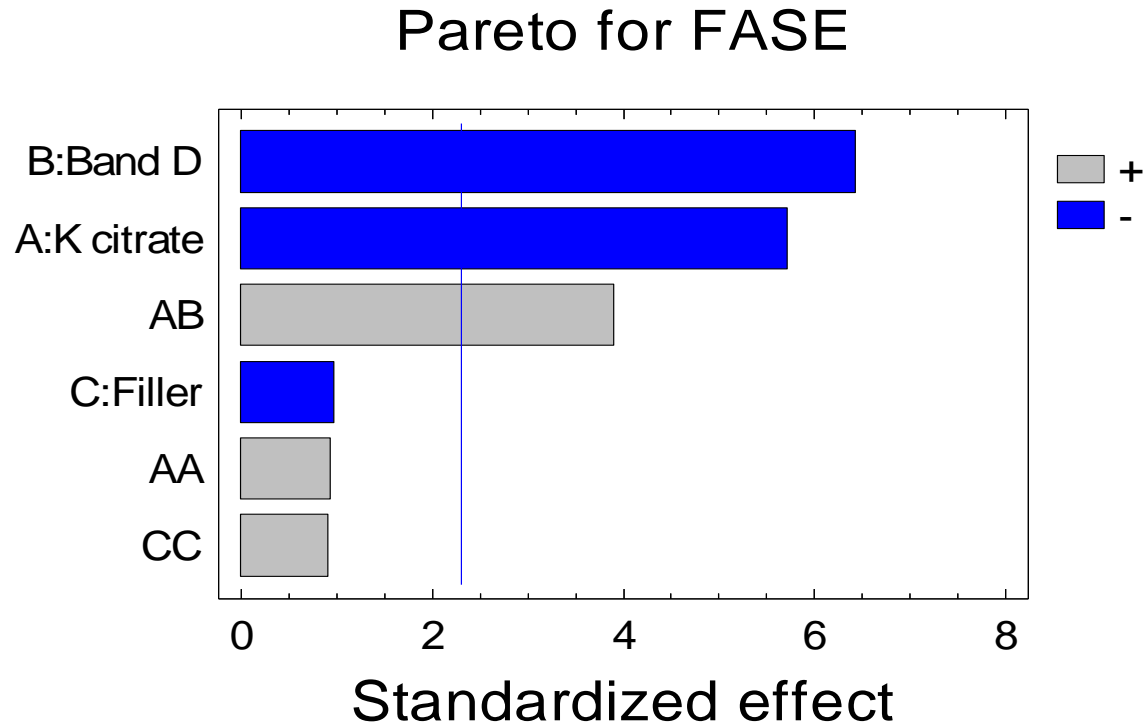
Results for CO



Main effects plot for CO



Results for FASE

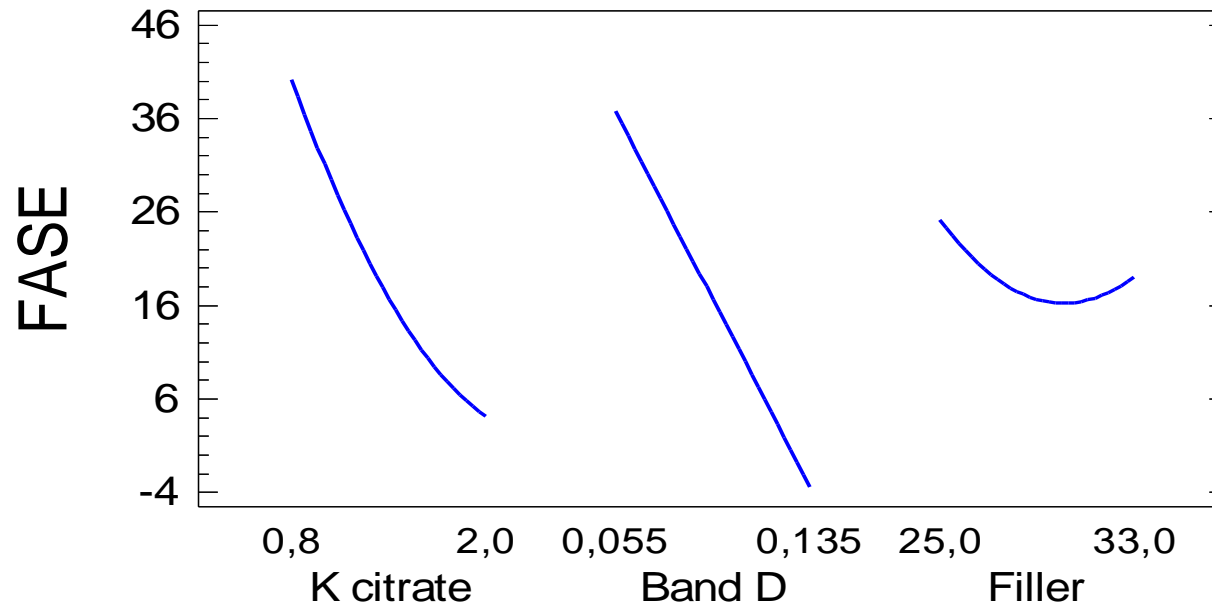


Band diffusion and K citrate in base paper have the same impact on FASE.

Strong interaction between them.

Results for FASE

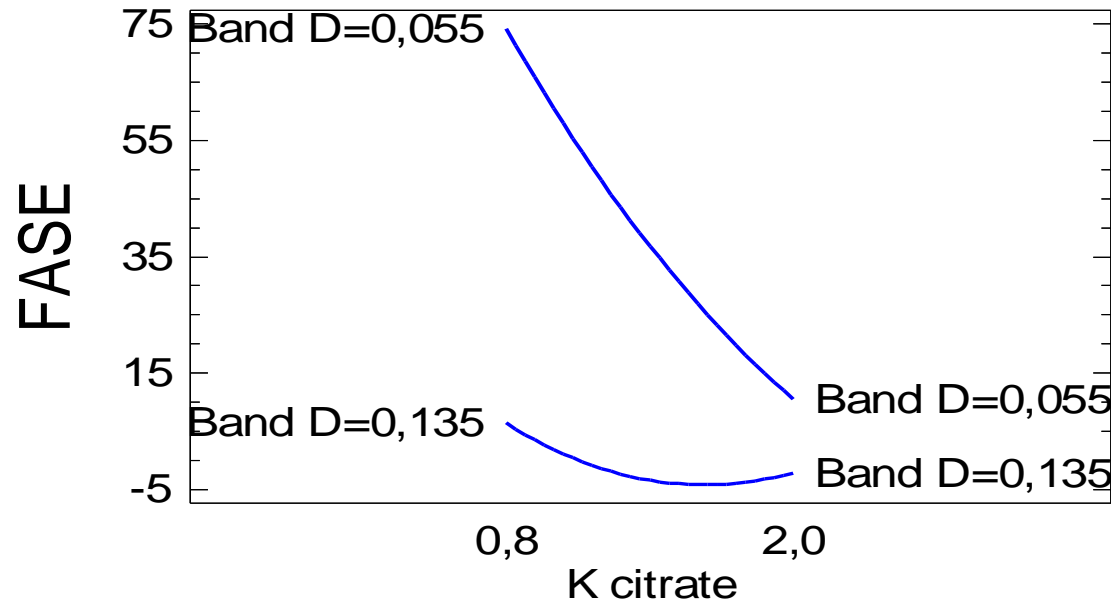
Main effects plot for FASE



Linear strong influence of both citrate and diffusion

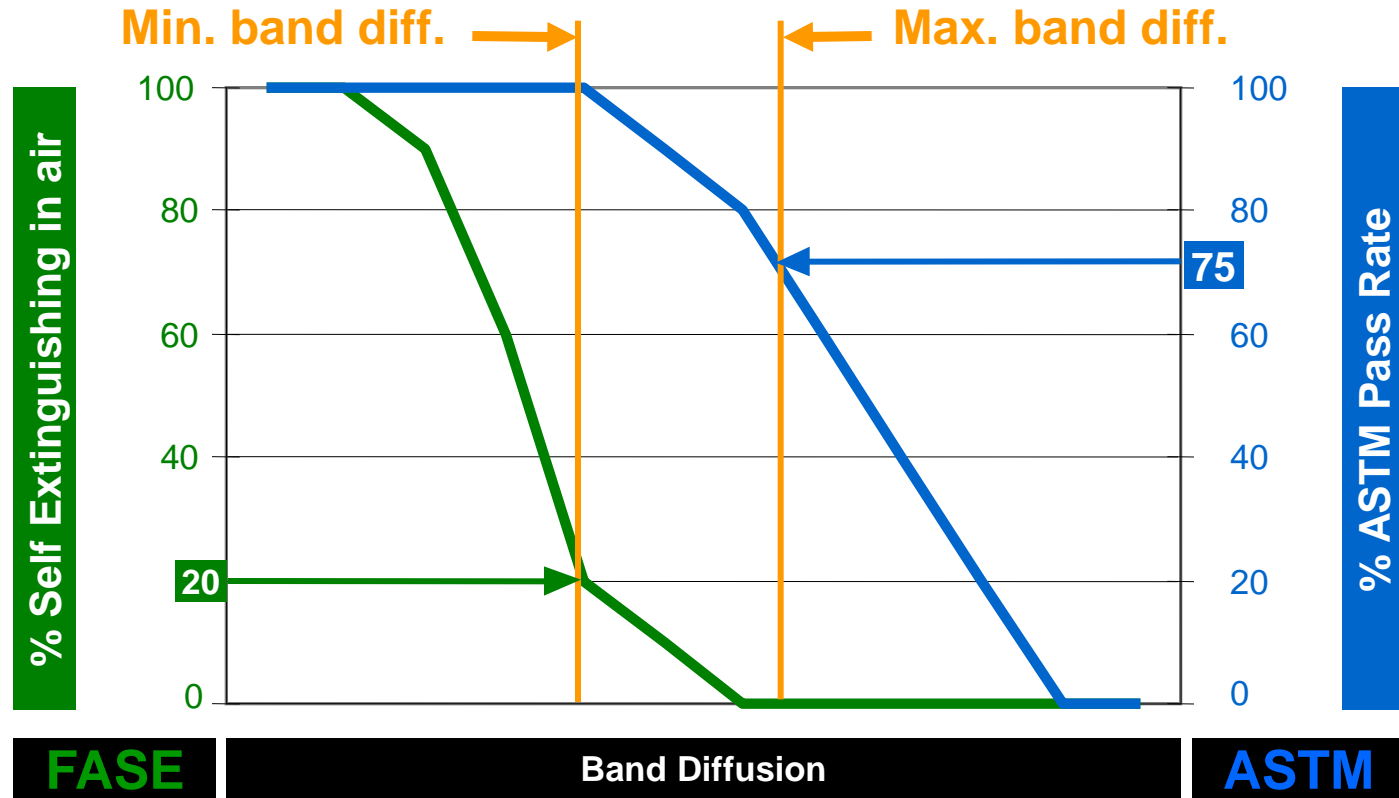
Results for FASE

Interactions plot for FASE



Interaction between citrate and band diffusion: Difficulty of 0-100 type of result.

D* Theory



Goal...
High ASTM / Low FASE

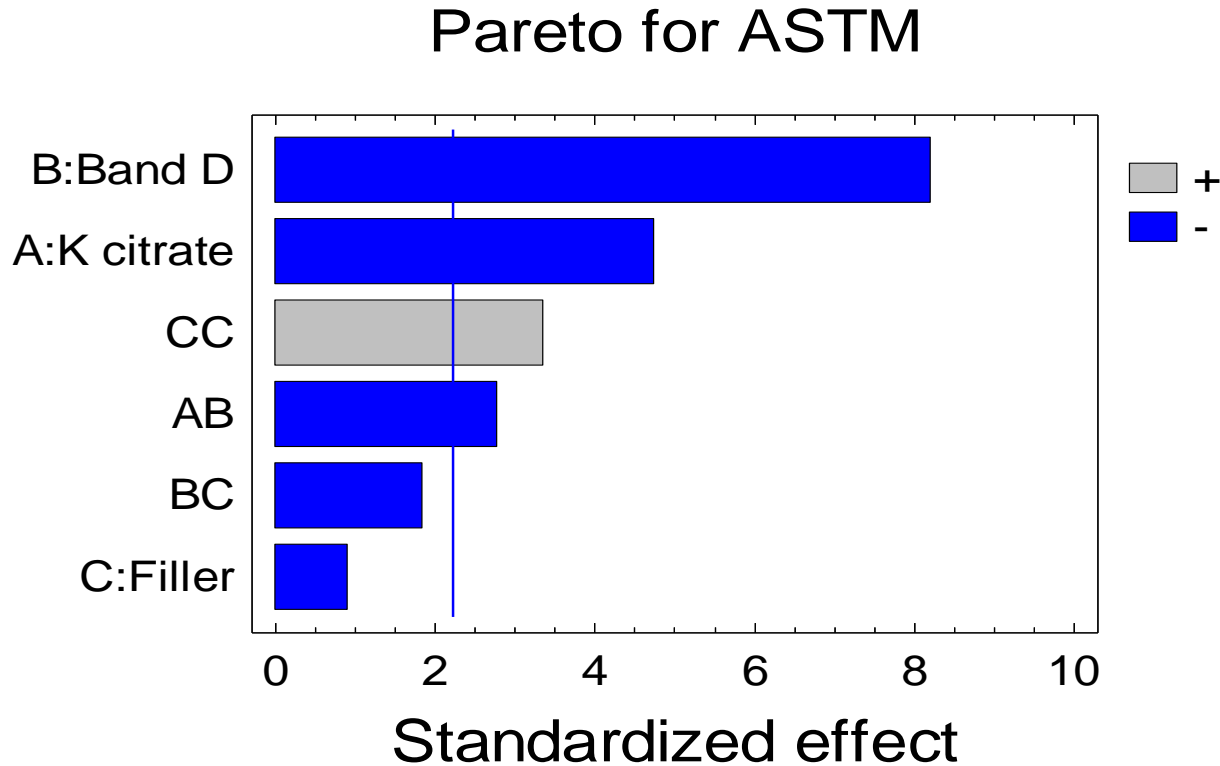
ASTM on 5 layers

ASTM with 5 layers of filter	US Blend	
	R ²	CoV
	87.8	7.1

The R² is high (87.8) and CV% is low (7.1%).

The model obtained for ASTM with 5 layers of paper filter is good.

Matrix results for ASTM

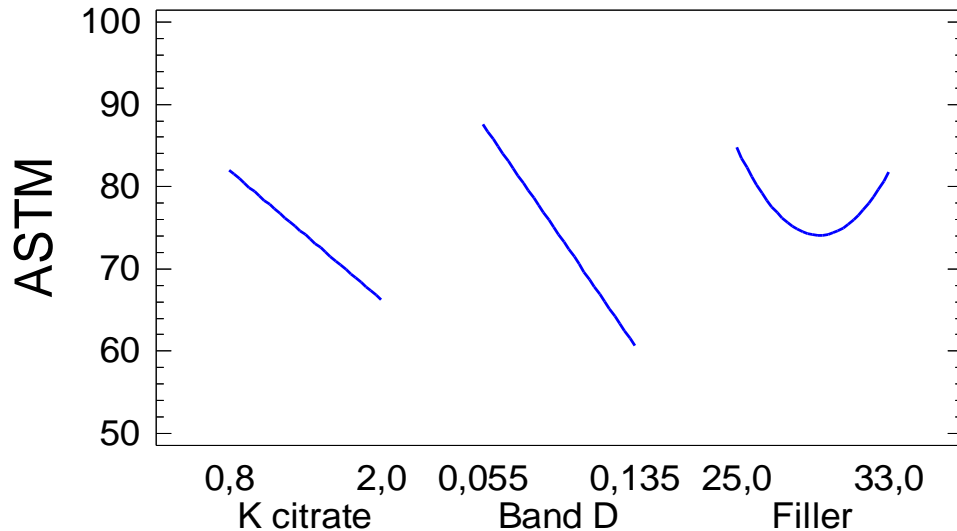


Citrate and band diffusion are the variables which have the greater effect on ASTM.

The interaction Cit x band diffusion (AB) is significant for the US blend.

Main effects for ASTM

Main effects plot for ASTM

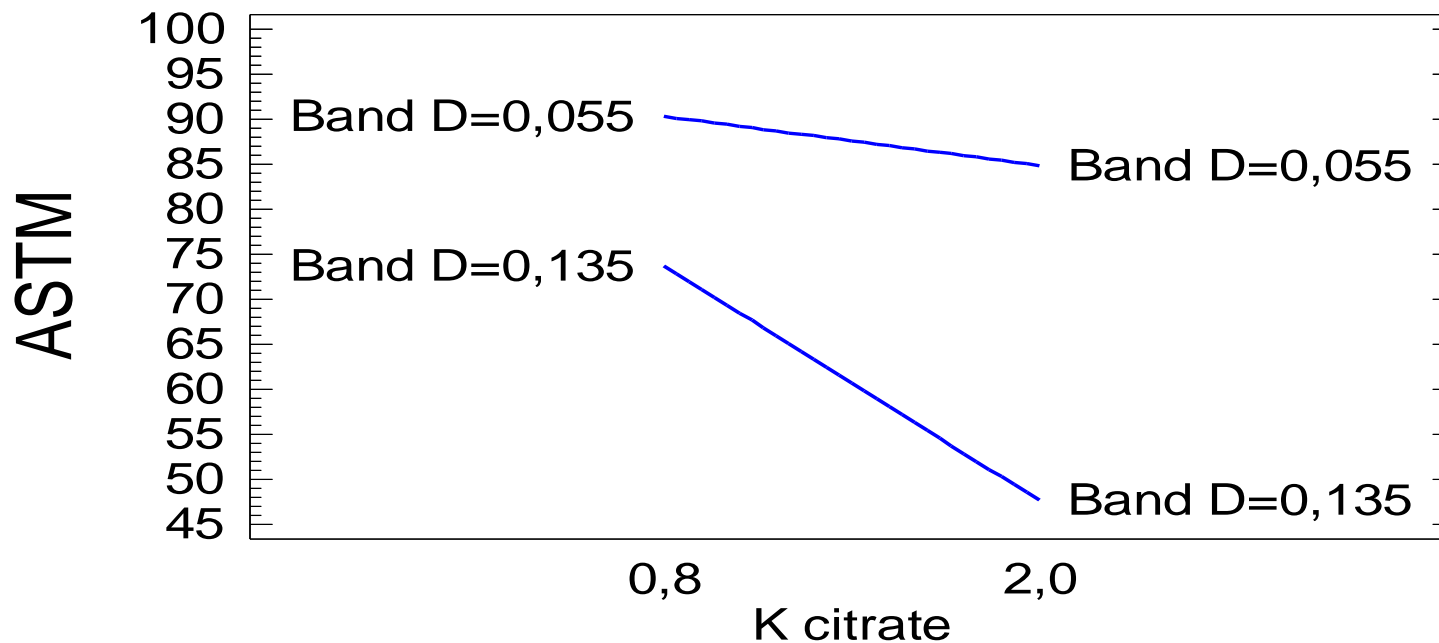


Increasing band diffusion from 0.020 cm/s decreases ASTM of 7%

Increasing citrate level from 0.3% decreases ASTM of 4 %

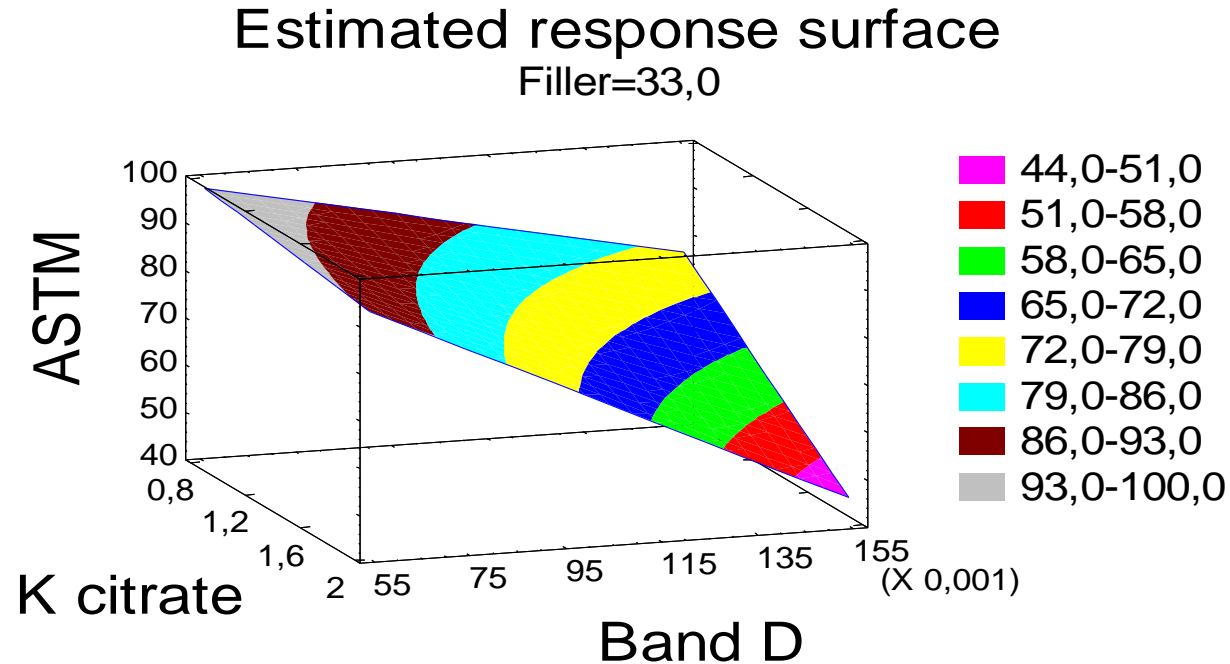
A quadratic effect exist for the filler (minimum for 29% filler).

Interaction plot for ASTM



The interaction Cit x band diffusion is significant

Interactions : Response surface



The effect of Kcit on ASTM is strong for the high level of band diffusion.
For the low level of band diffusion, the effect of Kcit on ASTM is small .

Conclusion

- Band diffusion and citrate have an equivalent impact on ASTM and FASE, but interactions have to be taken into account.
- For base paper parameters, K Citrate level has the strongest influence: it impacts puff number, CO deliveries, tar to a lower extent, ASTM and FASE.

But depending on the overall paper design including band diffusion, it is possible to adjust for CO or FASE without changing ASTM.

- Filler level only significantly impacts puff number, which then can be adjusted without changing the other parameters.
- Band D* has a major impact on ASTM and FASE, but also, to a lesser extent on CO deliveries.

- This study allowed us to measure that citrate and band diffusion have an equivalent impact on ASTM and FASE.
- This matrix study also allowed us to see that it is possible to adjust deliveries, ASTM and FASE independently, allowing to find the right combination for both regulations ; 10/1/10 and LIP.

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