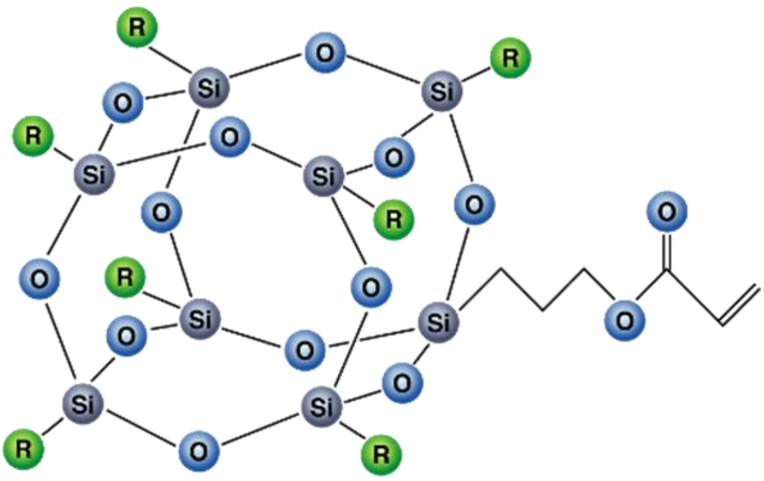
Taber Abrasion, Impact and Contact Angle testing of

Vitolane® coatings

Vitolane® is an affordable method of manufacturing silsesquioxanes (R-Si-$O_{1.5}$) with different functionalities.
These organic-inorganic hybrid resins can be added to coatings, adhesives and bulk polymers to enhance material properties such as improved abrasion resistance, increase resistance to solvents and better barrier properties.



R = functional group, which may be the same or may be different. For Vitolane AZ, R is alternating n-propyl and methacrylate functional groups on each silsesquioxane cage molecule

This report describes the tests done on a coating in which an ingredient has been replaced by Vitolane A and Vitolane AZ. The coatings are deposited by bar coating with thickness of 100µm and are cured by UV. The coatings are subjected to Taber testing, impact testing and contact angle.

Objective: To produce a chemical which improves the combined properties of increased wear resistance and adhesion, and low surface energy, suitable for wind turbine blade coatings.

1. Vitolane® formulations

Each of the formulations contains a number of ingredients. These are:

Code	Name	Role
CN132	Aliphatic epoxy diacrylate	Very low viscosity, high reactivity, excellent chemical resistance
SR454	Triacrylate monomer	High chemical resistance and low viscosity
SR9003	Diacrylate monomer	Good wetting properties and good flexibility
SR494	Tetrafunctional monomer	High reactivity and good scratch resistance
Vitolane A	Methacrylate functional oligomer	To improve cross-link density and abrasion resistance
Vitolane AZ	Methacrylate/n-propyl functional oligomer	To cross-link and reduce surface energy
184	Photoinitiator	Cure catalyst
BP	Photoinitiator	Cure catalyst

***Table 1**: Description of the ingredients comprising the formulation of the coatings.*

The specific formulations are:

Name	Formulation (wt %)							
	SR494	Vitolane A	Vitolane AZ	CN132	SR454	SR9003	184	BP
21116/A	9	0	0	27	27	27	5	5
21116/B	6	3	0	27	27	27	5	5
21116/C	3	6	0	27	27	27	5	5
21116/D	0	9	0	27	27	27	5	5
21116/E	0	0	9	27	27	27	5	5
21116/F	0	15	0	25	25	25	5	5
21116/G	0	20	0	23.3	23.3	23.3	5	5
21116/H	0	25	0	21.7	21.7	21.7	5	5
21116/I	0	30	0	20	20	20	5	5
21116/J	0	0	15	25	25	25	5	5
21116/K	0	0	20	23.3	23.3	23.3	5	5
21116/L	0	0	25	21.7	21.7	21.7	5	5
21116/M	0	0	30	20	20	20	5	5

***Table 2**: Formulation of the 13 coatings.*

The control coating is A. For all the others the ingredient SR494 has being replaced by Vitolane A or Vitolane AZ. Vitolane A is a silsesquioxane with a methacrylate, which give to the coating the property to be cured. Vitolane AZ is composed of a methacrylate group and an n-propyl group. This second group gives to the coating the property to decrease the surface energy.

Taber Wear Testing

	Average (Taber Wear Index)	Deviation
A	1.9	0.62
B	2.7	1.38
C	3.9	0.37
D	16.9	0.76
E	0.8	0.53
J	3.4	1.00
K	1.8	1.45
L	3.6	2.00
M	2.1	0.84

Table 3: *Average Taber wear index calculated with the loss of weight during the abrasion experiments and the deviation of the results comparing to the average.*

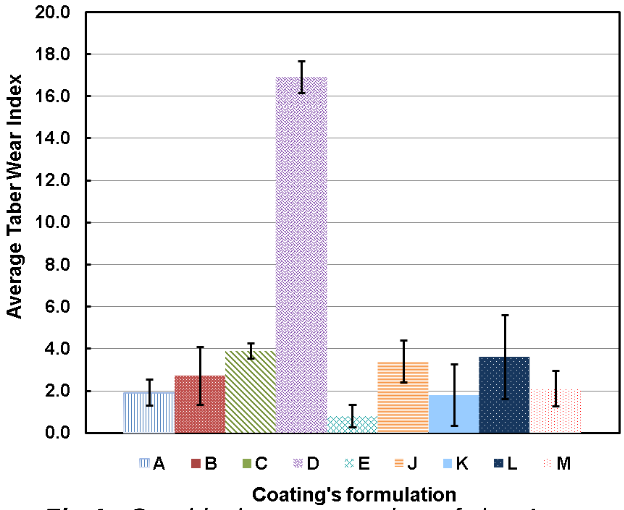


Fig.1: *Graphical representation of the Average Taber wear index for each coating formulation, and the deviation.*

Impact Testing

Coating	Average Impact force (g.m)	Deviation (g.m)
A	387	36
B	390	7
C	307	9
D	273	18
E	283	16
F	213	16
G	197	11
H	137	51
I	110	33
J	240	40
K	293	36
L	233	24
M	293	31

Table 4: *Average impact force and the deviation between the three samples and the average.*

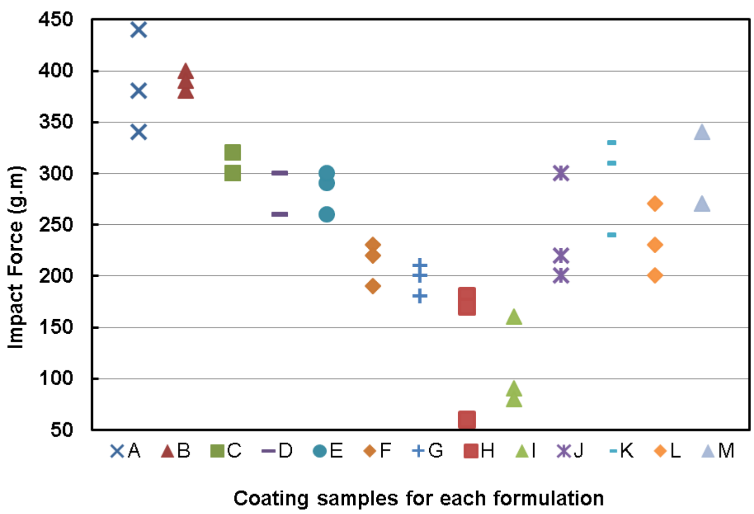


Fig.2: *Impact force represented for each sample of each formulation.*

c) Contact angle

	Contact angle water (°)	Contact angle diiodo (°)	Total Surface Energy (mN/m)
A	77.2	68	33.15
B	84.1	64.7	31.15
C	76.1	57.4	37.57
D	82.7	64.1	32.00
E	92.4	64.9	28.19
F	62.8	44	49.27
G	59.5	36.8	53.38
H	65	45	47.71
I	55.5	40	54.60
J	93.1	64.3	28.31
K	92.3	63.6	28.82
L	93	63.8	28.57
M	93.9	66.2	27.2

Table 5: *Contact angle for each liquid (water and diiodo) and total surface energy for each coating.*

4) Conclusion

It can be conclued that the compound Vitolane AZ increases the hydrophobicity of the coating.
The formulation B seems to have the best behaviour during the impact tests, and the formulation E have the best behaviour for the abrasion. The coating E is more hydrophobic than the coating reference A, and its resistance to impact is quite good.

Formulation E had the best overall properties and contained 9 wt% Vitolane AZ.

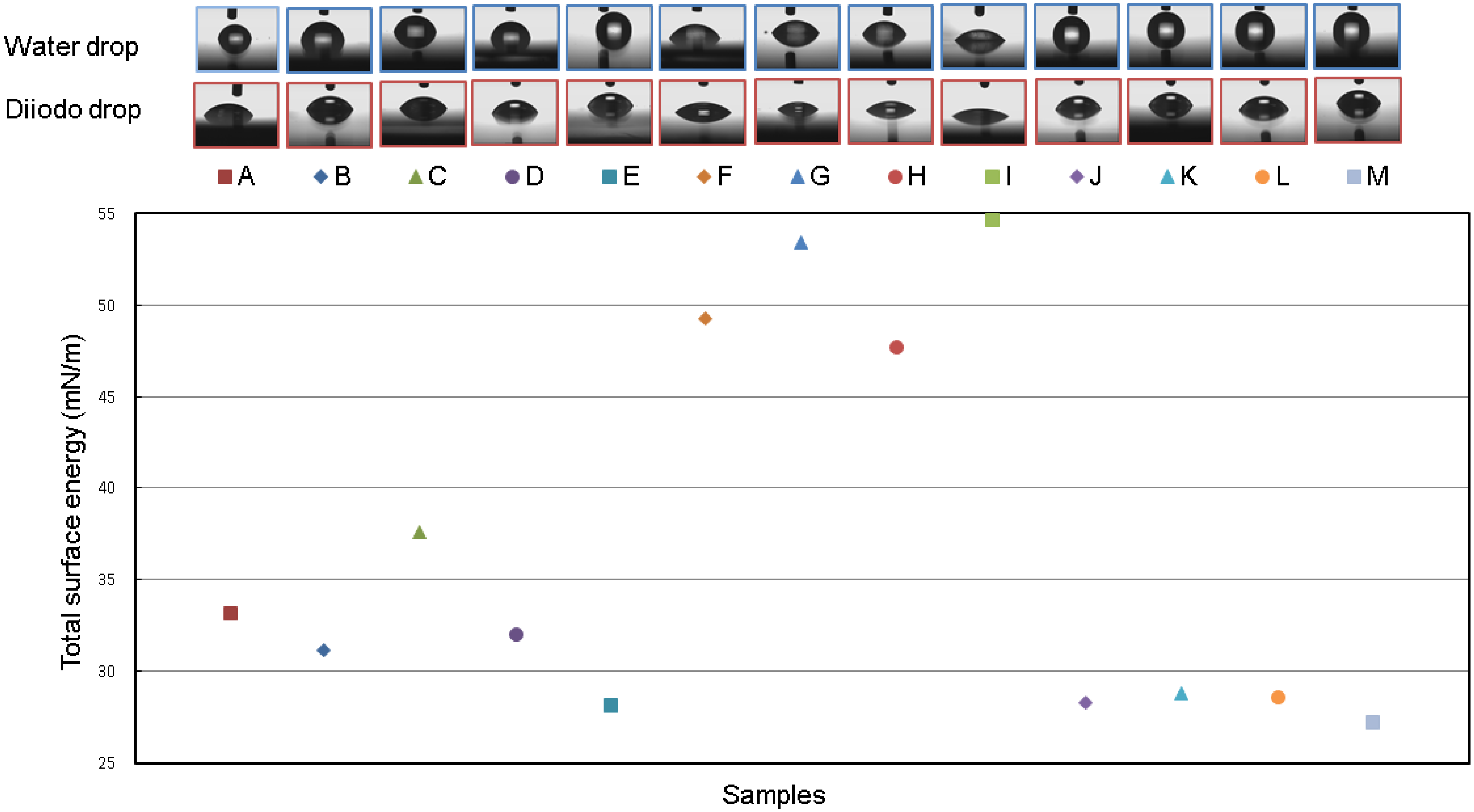


Fig.3: *Total surface energy measured for each coating and pictures of the drop of water and diiodo methane which lead to the contact angle measurement*

Appendix I: Summary Chart

Name	Formulation (wt %)								Coating				Impact testing		Taber testing		Contact Angle
	SR494	Vitolane A	Vitolane AZ	CN132	SR454	SR9003	184	BP	Coating date	Number of samples	UV cure passes/% UV	Nb of panel deterioration 25/06/2012	Average Impact potential energy ($J.s^2.m^{-1}$)	Deviation ($J.s^2.m^{-1}$)	Average (Taber Wear Index)	Deviation	Total Surface Energy (mN/m)
21116/A	9	0	0	27	27	27	5	5	18/06/2012	7	5/ 65%	0	0.387	0.036	1.9	0.62	33.15
21116/B	6	3	0	27	27	27	5	5	18/06/2012	7	5/ 65%	0	0.390	0.007	2.7	1.38	31.15
21116/C	3	6	0	27	27	27	5	5	19/06/2012	7	5/ 65%	0	0.307	0.009	3.9	0.37	37.57
21116/D	0	9	0	27	27	27	5	5	19/06/2012	7	5/ 65%	0	0.273	0.018	16.9	0.76	32.00
21116/E	0	0	9	27	27	27	5	5	19/06/2012	7	5/ 65%	0	0.283	0.016	0.8	0.53	28.19
21116/F	0	15	0	25	25	25	5	5	20/06/2012	7	5/ 65%	1	0.213	0.016			49.27
21116/G	0	20	0	23.3	23.3	23.3	5	5	20/06/2012	7	5/ 65%	1	0.197	0.011			53.38
21116/H	0	25	0	21.7	21.7	21.7	5	5	20/06/2012	7	5/ 65%	2	0.137	0.051			47.71
21116/I	0	30	0	20	20	20	5	5	21/06/2012	7	5/ 65%	1	0.110	0.033			54.60
21116/J	0	0	15	25	25	25	5	5	21/06/2012	7	5/ 65%	0	0.240	0.040	3.4	1.00	28.31
21116/K	0	0	20	23.3	23.3	23.3	5	5	21/06/2012	7	5/ 65%	0	0.293	0.036	1.8	1.45	28.82
21116/L	0	0	25	21.7	21.7	21.7	5	5	21/06/2012	7	5/ 65%	0	0.233	0.024	3.6	2.00	28.57
21116/M	0	0	30	20	20	20	5	5	22/06/2012	7	5/ 65%	1	0.293	0.031	2.1	0.84	27.2

Formulation which gives the best adhesion

Formulation which gives the best abrasion resistance

Formulations which gives a dis-bonding coating

Appendix II: Average impact potential energy and Taber wear index for the different coating formulations