Hydrophobic Waterborne Hybrid (Alkyd/Styrene Acrylic) Latexes

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- Developing technology
- Increasing population
- Industrialization

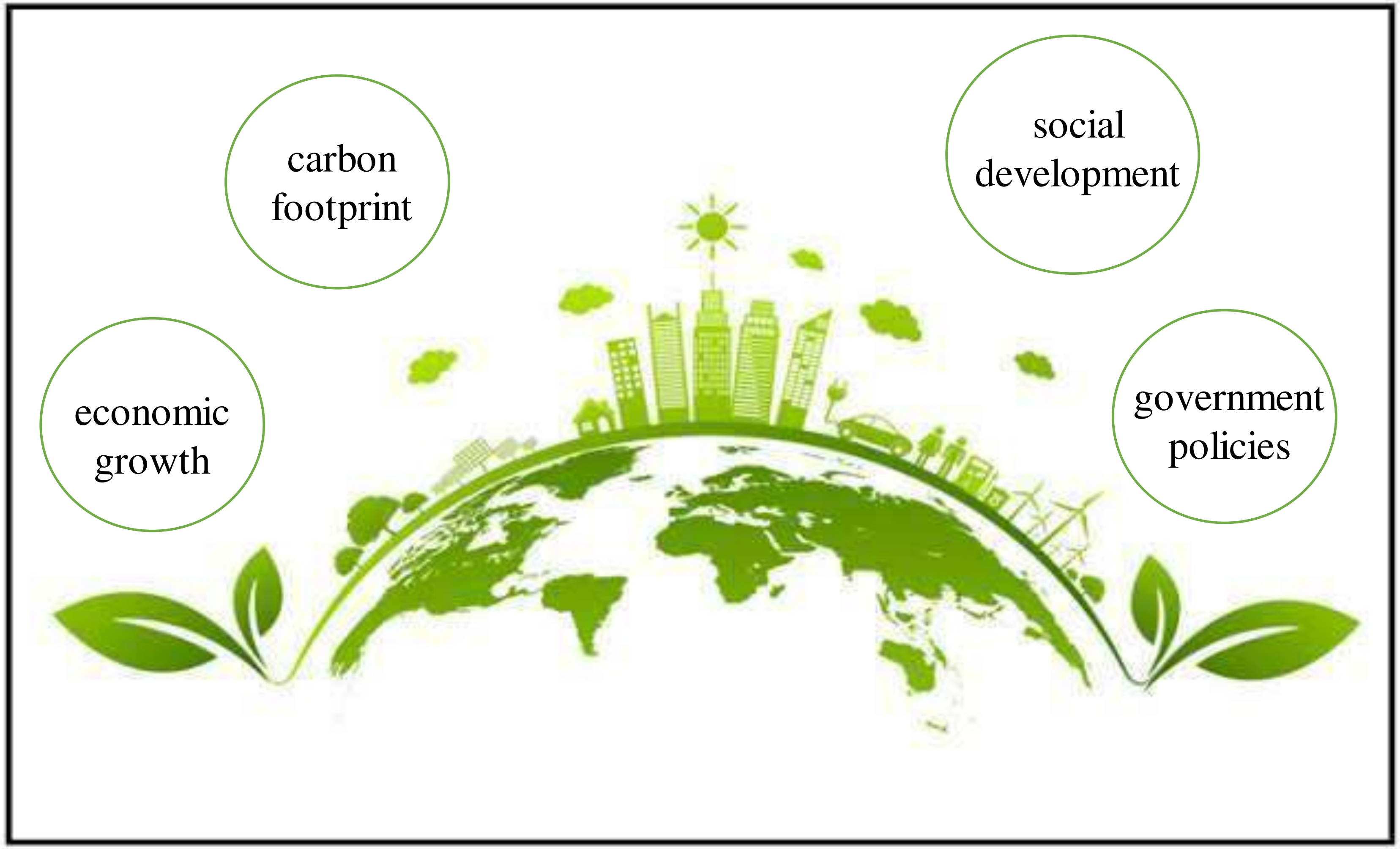
- Material requirement
- Cost

Composite Materials

Hybrid Materials

- Disruption of supply-demand balance
- Shortage of raw materials

This technology offers the possibility of combinations of at least two different, normally incompatible materials, combining certain properties that cannot be achieved in a single polymer by either component alone.


carbon footprint
social development
economic growth
government policies

Waterborne Hybrid Materials

- solvent-free
- low toxicity
- lower costs
- sustainability
- green chemistry

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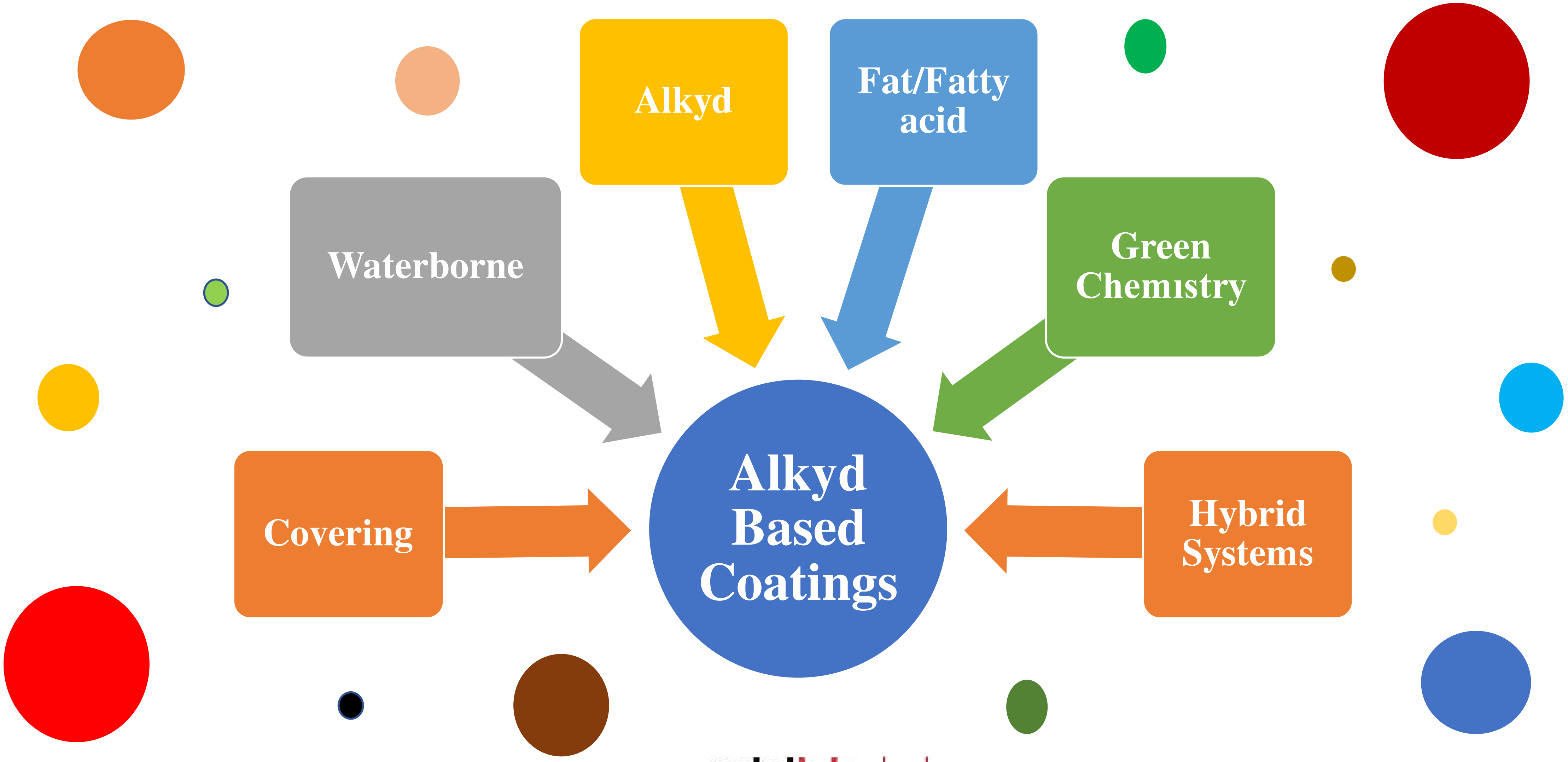
ChemMedia by Artkim Group

In recent years, waterborne formulations have dominated the architectural paint market due to their low VOC, odor and toxicity.


Alkyd
Fat/Fatty acid
Waterborne
Green Chemistry
Covering
Alkyd Based Coatings
Hybrid Systems

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Waterborne hybrid (alkyd/styrene acrylic) emulsion polymers and exterior paint applications

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Synthesis of Hydrophobic Waterborne Hybrid (Alkyd/Styrene Acrylic) Latexes

- *Alkyd resin synthesis*

Why hemp seed oil (HSO)?

	HSO
Chemical form	Triglyceride
Acid value (mg KOH/ g sample)	5,47
Iodine index(g I_2/100g)	160
Oil lenght (%)	60
Drying index	86
Class	Drying oils
Linoleik asit (%)	56
Oleic acid (%)	18

- ***Alkyd resin synthesis***

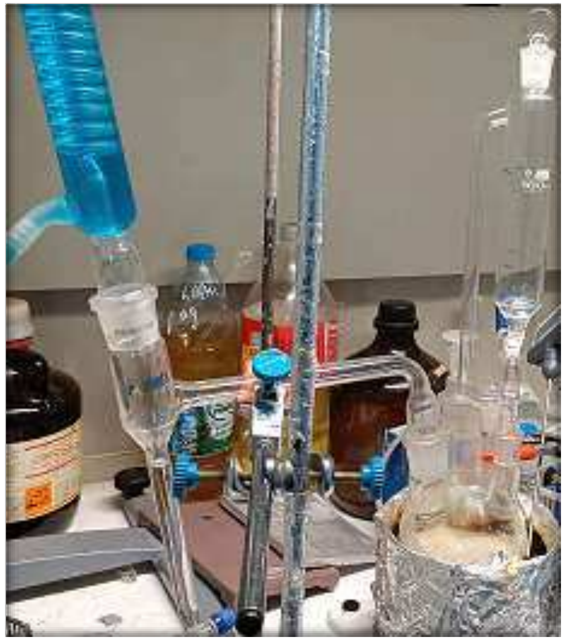
Table 1. Formulation of alkyd resin synthesis

Alkyd synthesis	Functions	Suppliers
Pentaerythritol	Polyalcohol	Acros Organic Company, Belgium
Phthalic anhydride	Polybasic acid	Sigma Aldrich, USA
Xylene	Solvent (reflux)	Sigma Aldrich, USA
o-Phosphoric acid	Catalys	Fluka, Turkey
Lithium stearate	Catalyst	Sigma Aldrich, USA

Hemp

Hemp seed

Hemp seed oil

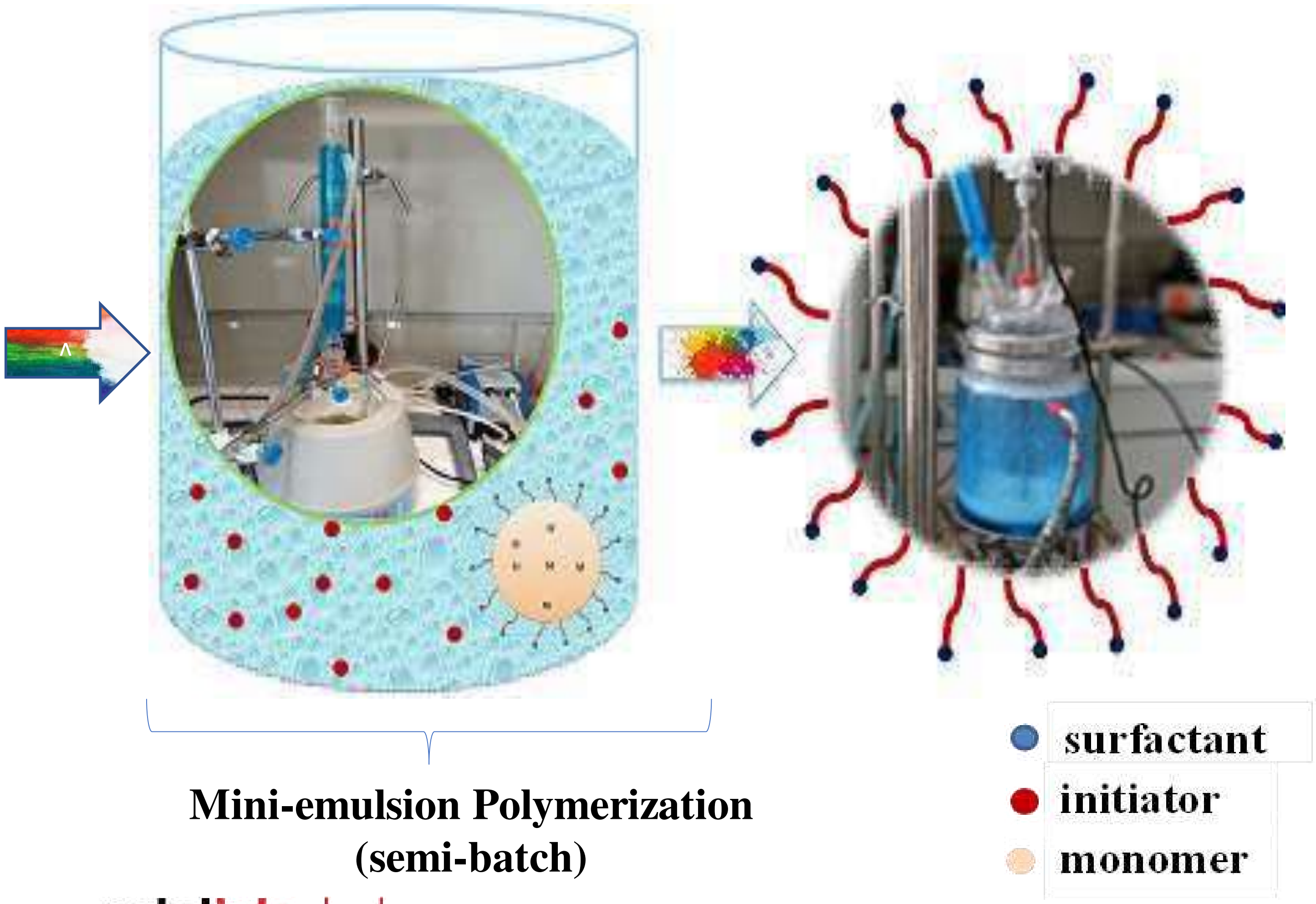


Monoglyceride (Alcolysis) Method

• *Synthesis of Hydrophobic Waterborne Hybrid (Alkyd/Styrene Acrylic) Latexes*

Table 2. Formulation of hydrophobic waterborne hybrid (alkyd/styrene acrylic) latexes

Polymer emulsion	Functions	Suppliers
Styrene (Sty)	Comonomer	Betek Boya, Turkey
Butyl acrylate (BA)	Comonomer	Betek Boya, Turkey
Acrylic acid (AA)	Comonomer	ZAG Kimya, Turkey
2,2,2-trifluoroethyl methacrylate (TFEMA)	Hydrophobic monomer	Sigma Aldrich, USA
Triethoxyvinyl silane (VTES)	Hydrophobic monomer	Acros Organic Company, Belgium
Span 80	Nonionic surfactant	Sigma Aldrich, USA
Exosel 073	Anionic surfactant	Betek Boya, Turkey
Hexadecane (HD)	Cosurfactant	Sigma Aldrich, USA
Potasyum Persülfate (KPS)	Initiator	Merck, Germany

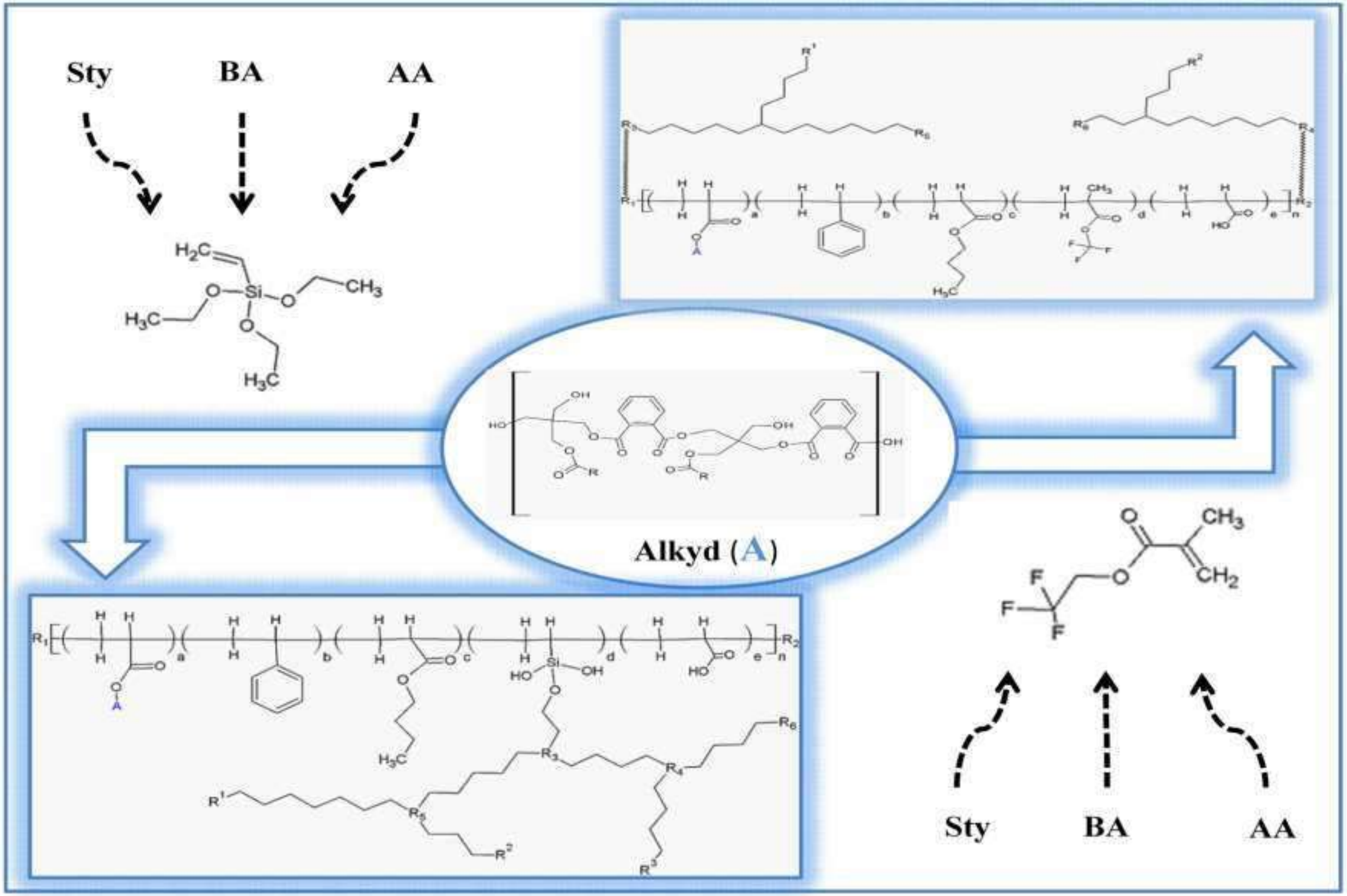


Mini-emulsion Polymerization (semi-batch)

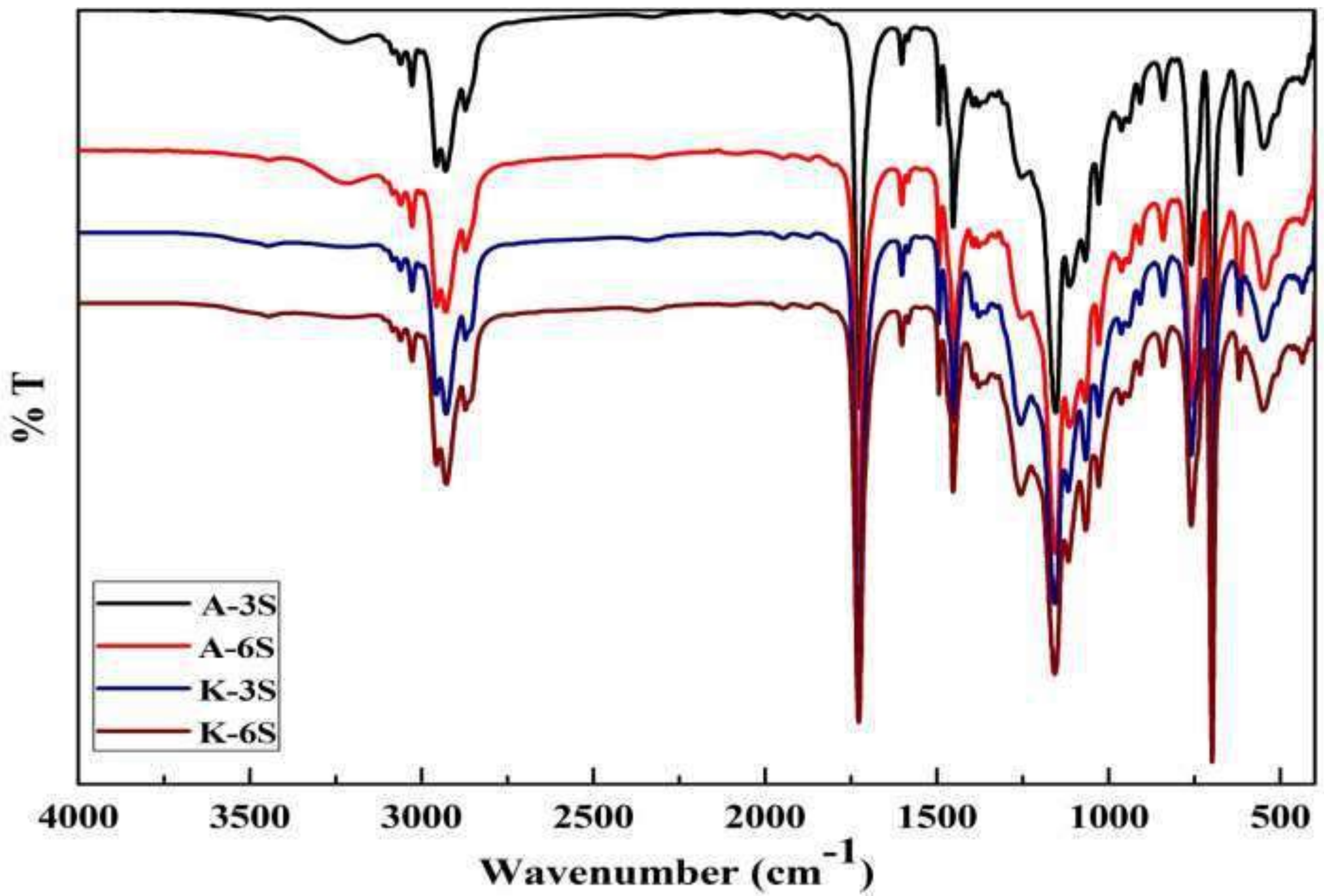
	A-3S	*A-3F*	*A-6S*	*A-6F*	*K-3S*	*K-3F*	*K-6S*	*K-6F*
HSO based-Alkyd[a]	-	-	-	-	10	10	10	10
VTES[a]	3	-	6	-	3	-	6	-
TFEMA[a]	-	3	-	6	-	3	-	6
Sty[a]	47.5	47.5	46.0	46.0	42.5	42.5	41.0	41.0
BA[a]	47.5	47.5	46.0	46.0	42.5	42.5	41.0	41.0
AA[a]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
HD[a]	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Span 80[a]	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Exosel 073[a]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
DIW[b]	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Initiator-I								
KPS[a]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Initiator-II								
KPS [a]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total (g)	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0

- A-3S; latex containinng 3% VTES
- A-6S; latex containinng 6% VTES
- A-3F; latex containinng 3% TFEMA
- A-6F; latex containinng 6% TFEMA
- K-3S; latex containinng alkyd and 3% VTES
- K-6S; latex containinng alkyd and 6% VTES
- K-3F; latex containinng alkyd and 3% TFEMA
- K-6F; latex containinng alkyd and 6% TFEMA

[a] *% of monomer amount,*
[b] 50% of total weight


Sty
BA
AA
Alkyd (A)
Sty
BA
AA

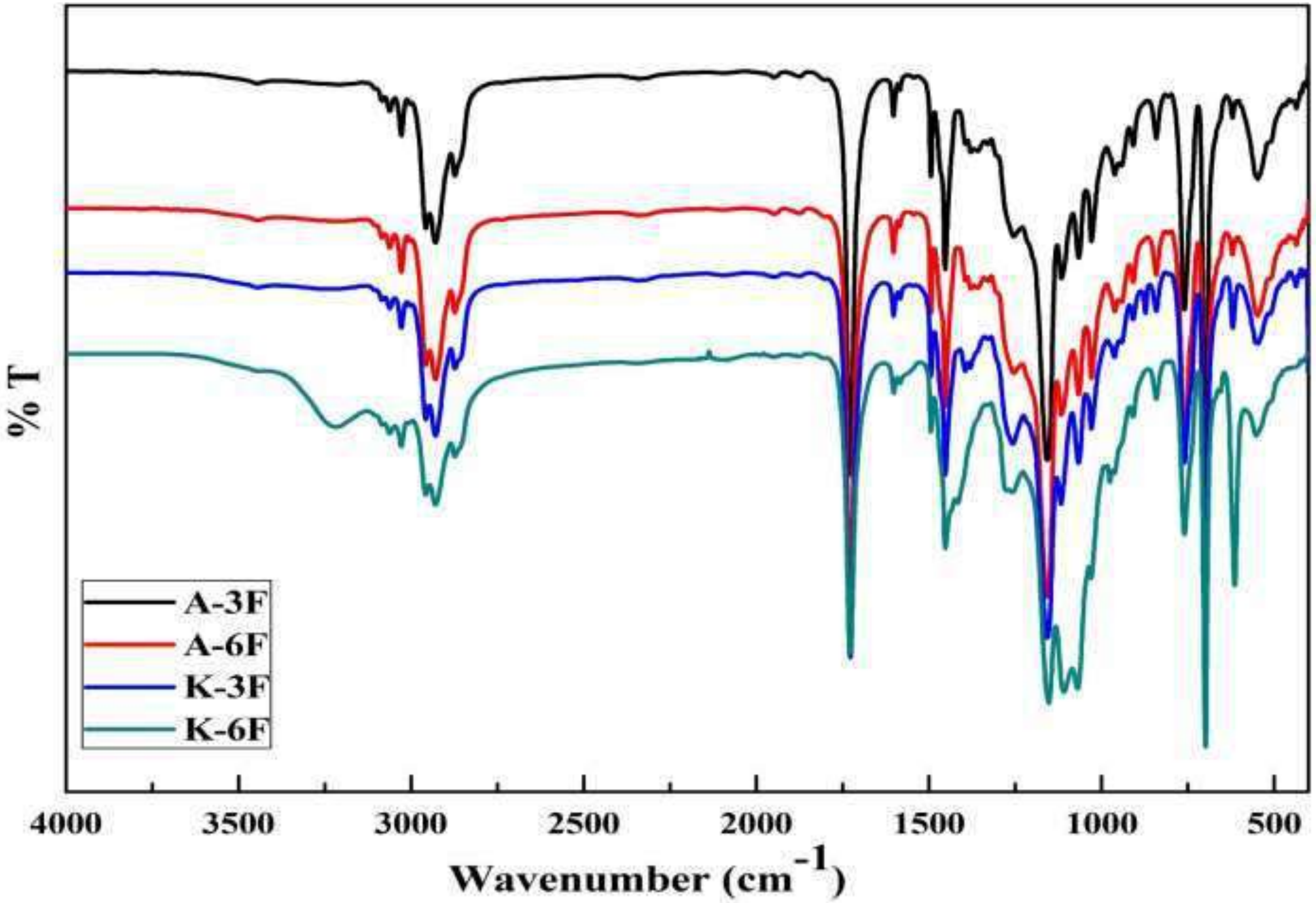
- ***Tests and measurements***



cm^{-1}	
3600-3300	-OH
3300-3000	=CH
3030	Ar-H
3000-2700	–C-H (-CH_3, -CH_2 ve -CH groups)
1727	C=O
1675-1500	C=C (aliphatic/aromatic)
1150	C-O
750	ortho disubstituted benzene

Figure 1. FTIR spectra of VTES-containing waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***



cm^{-1}	
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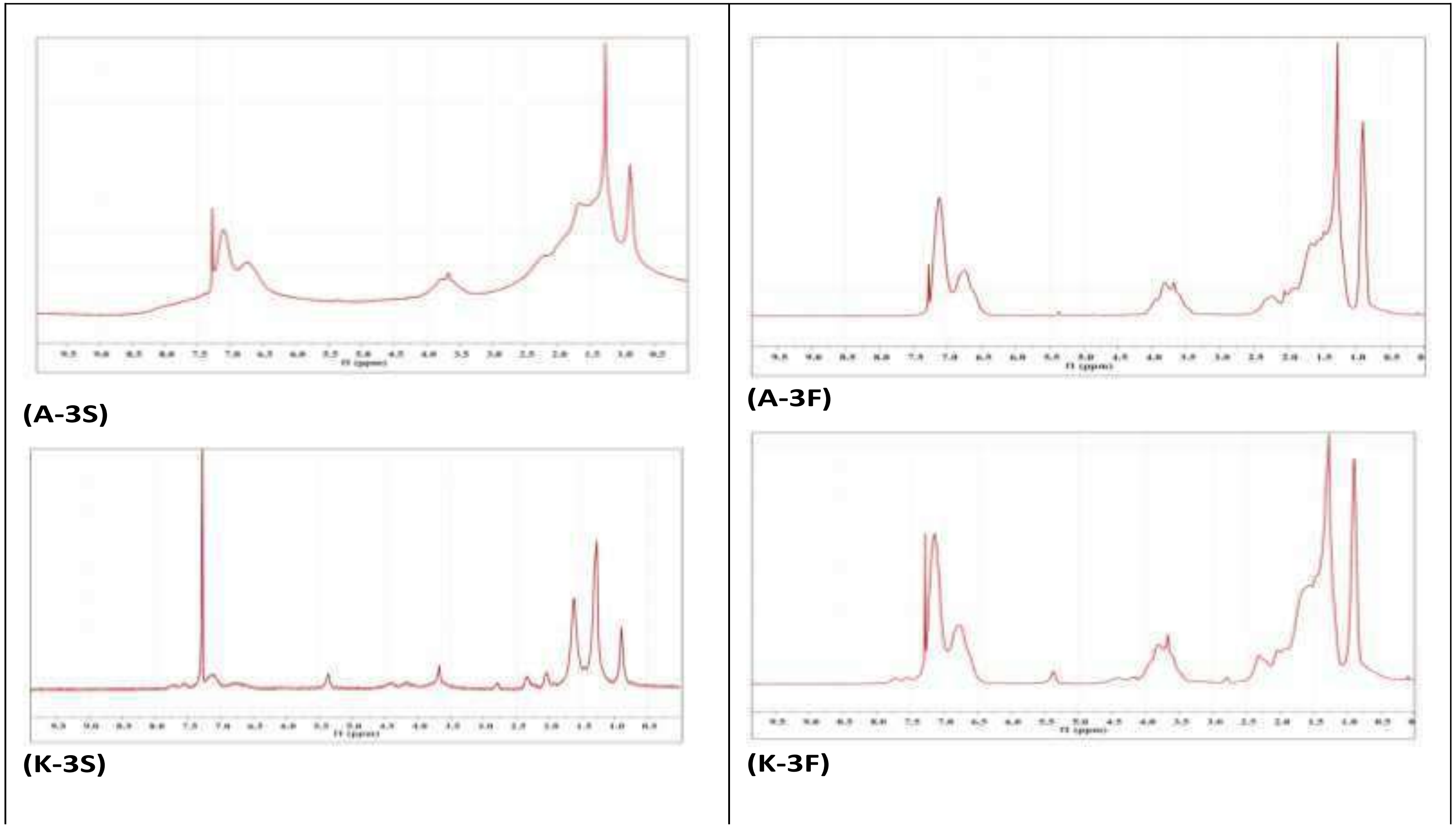
3000-2700	–C-H (-CH_3, -CH_2 ve -CH groups)
1727	C=O
1675-1500	C=C (aliphatic/aromatic)
1150	C-O
750	ortho disubstituted benzene

Figure 2. FTIR spectra of TFEMA-containing waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***



CHF; 4.70 ppm

Si-C; 1.50 ppm

Figure 3. ^{1}H-NMR spectra of waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***

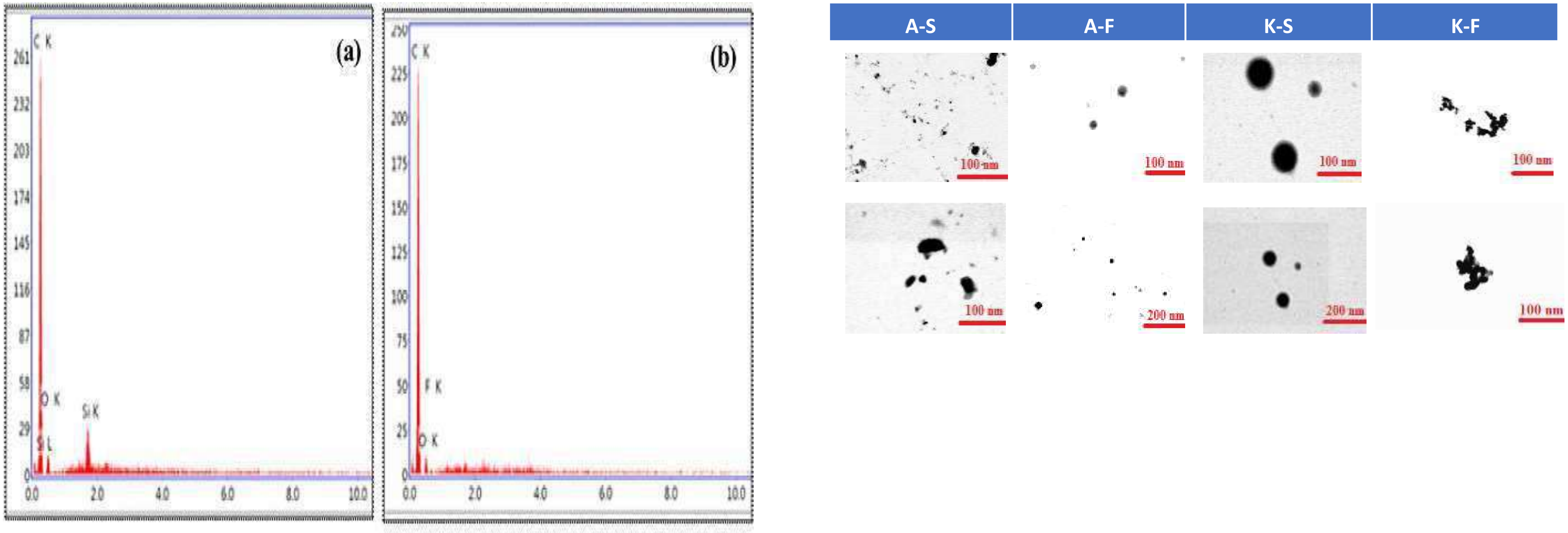


Figure 4. EDAX and STEM images of waterborne hydrophobic hybrid (alkyd/styrene acrylic) latex films containing VTES (a) ve TFEMA (b)

- ***Tests and measurements***

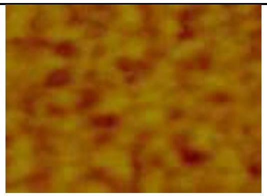
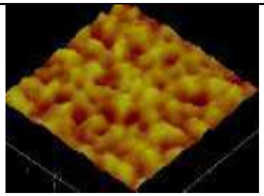
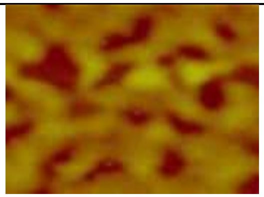
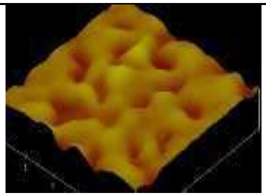
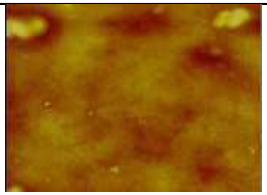
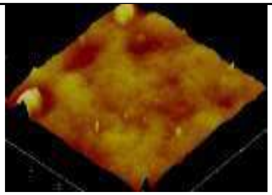
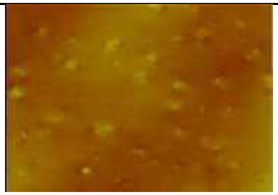
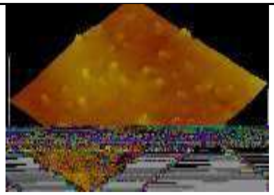
A-3S		A-3F	
Phase	Height (3D) (Rq= 12.163 nm, Ra= 9.621nm)	Phase	Height (3D) (Rq= 21.956 nm, Ra= 17.009nm)
			
K-3S		**K-3F**	
Phase	Height (3D) (Rq= 5.525 nm, Ra= 3.989 nm)	Phase	Height (3D) (Rq= 3.469 nm, Ra= 2.789 nm)
			

Figure 5. Phase contrast and topographic (5 µm×5 µm) AFM images of waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***

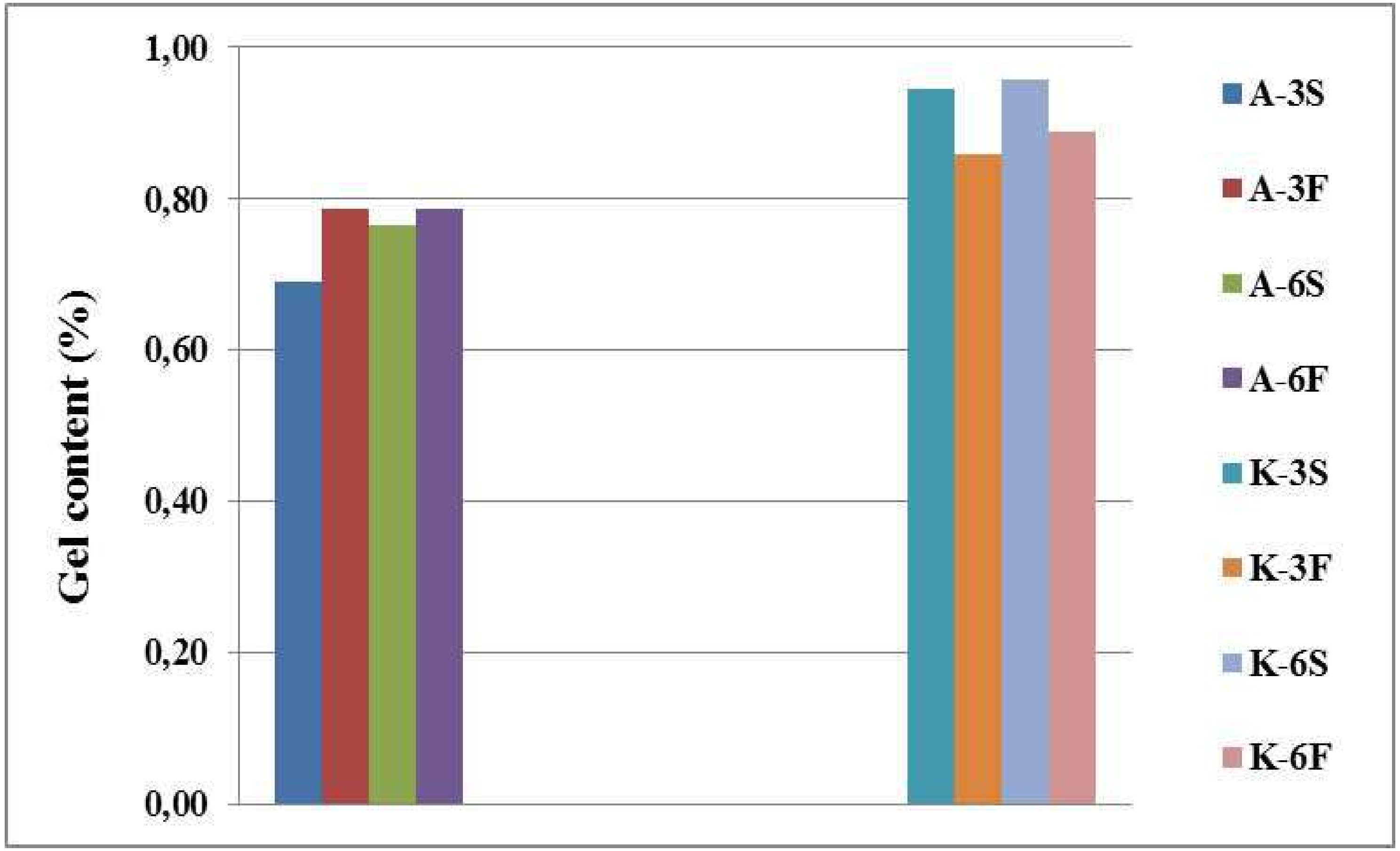


Figure 6. Gel content of waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***

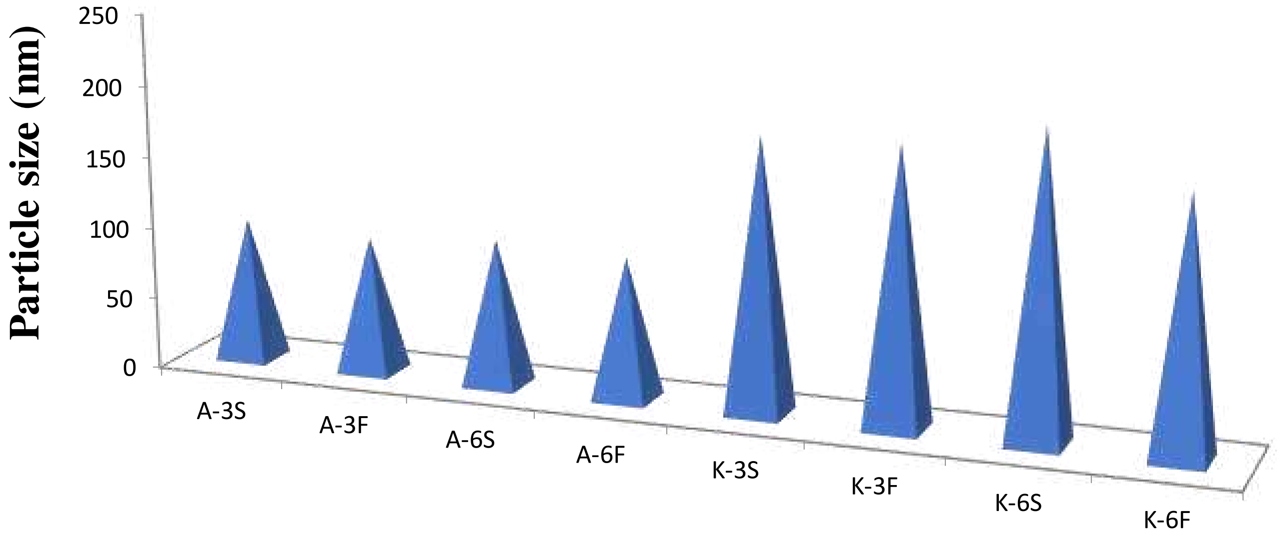


Figure 7. Particle size of waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***

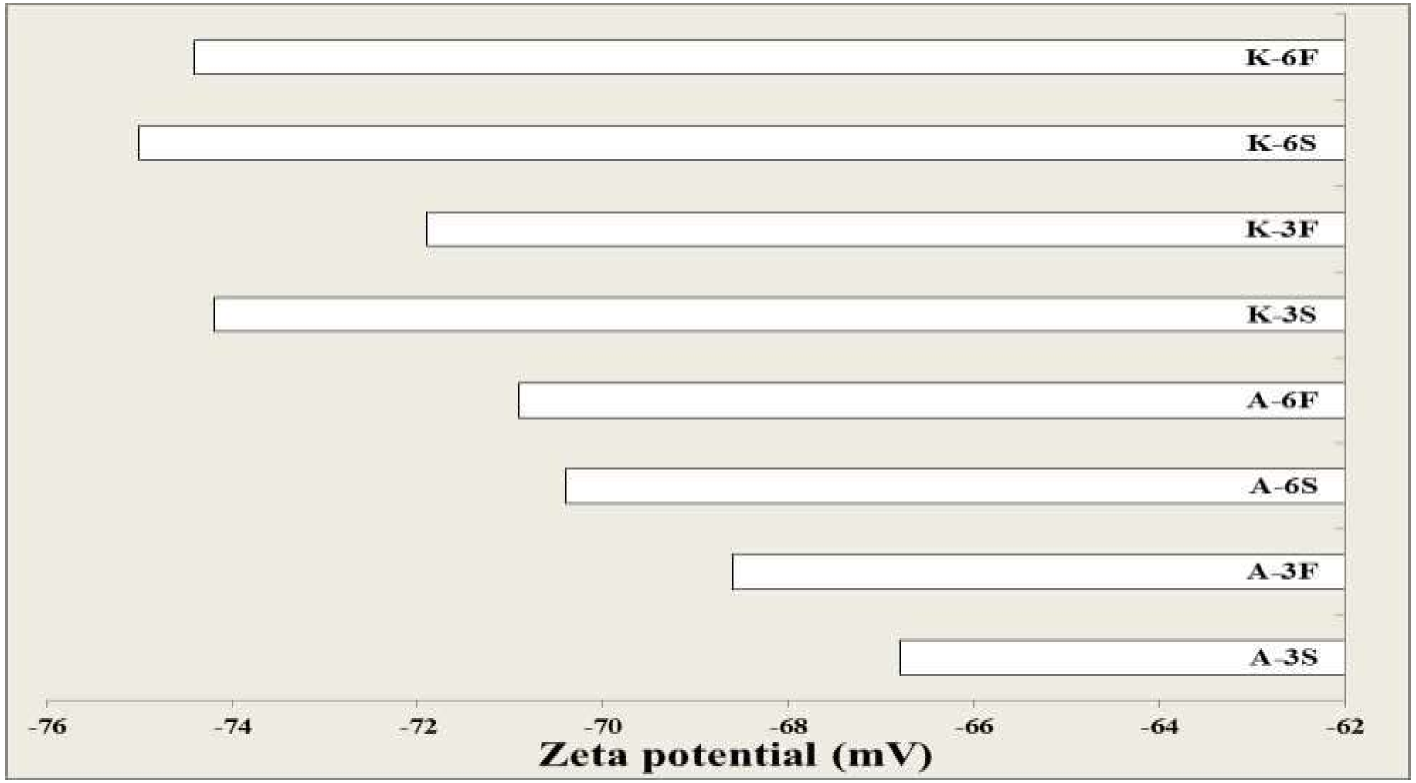


Figure 8. Zeta potential of waterborne hydrophobic hybrid (alkyd/styrene acrylic) polymer latexes

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- ***Tests and measurements***

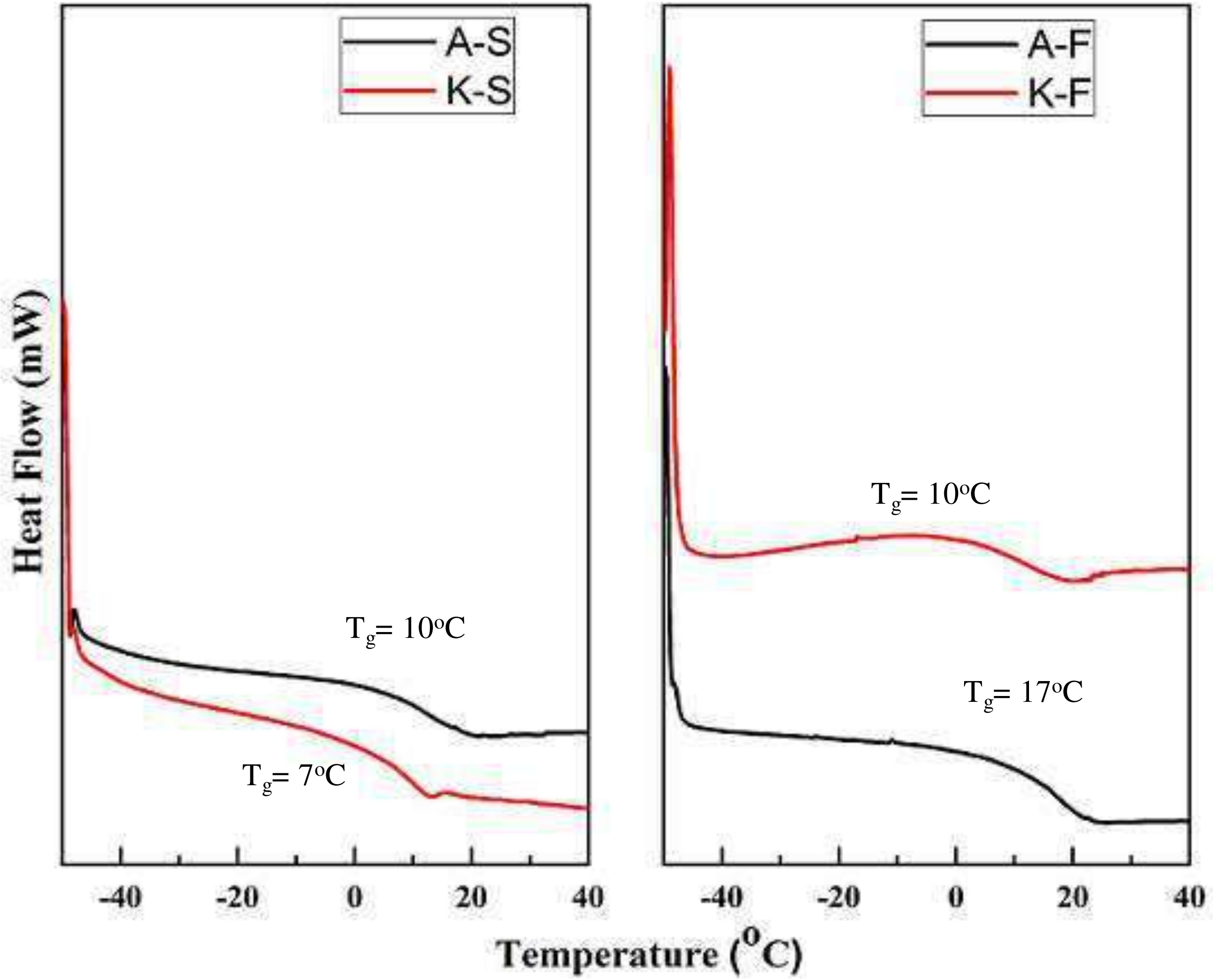

Figure 9. DSC curves of VTES and TFEMA-containing waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***

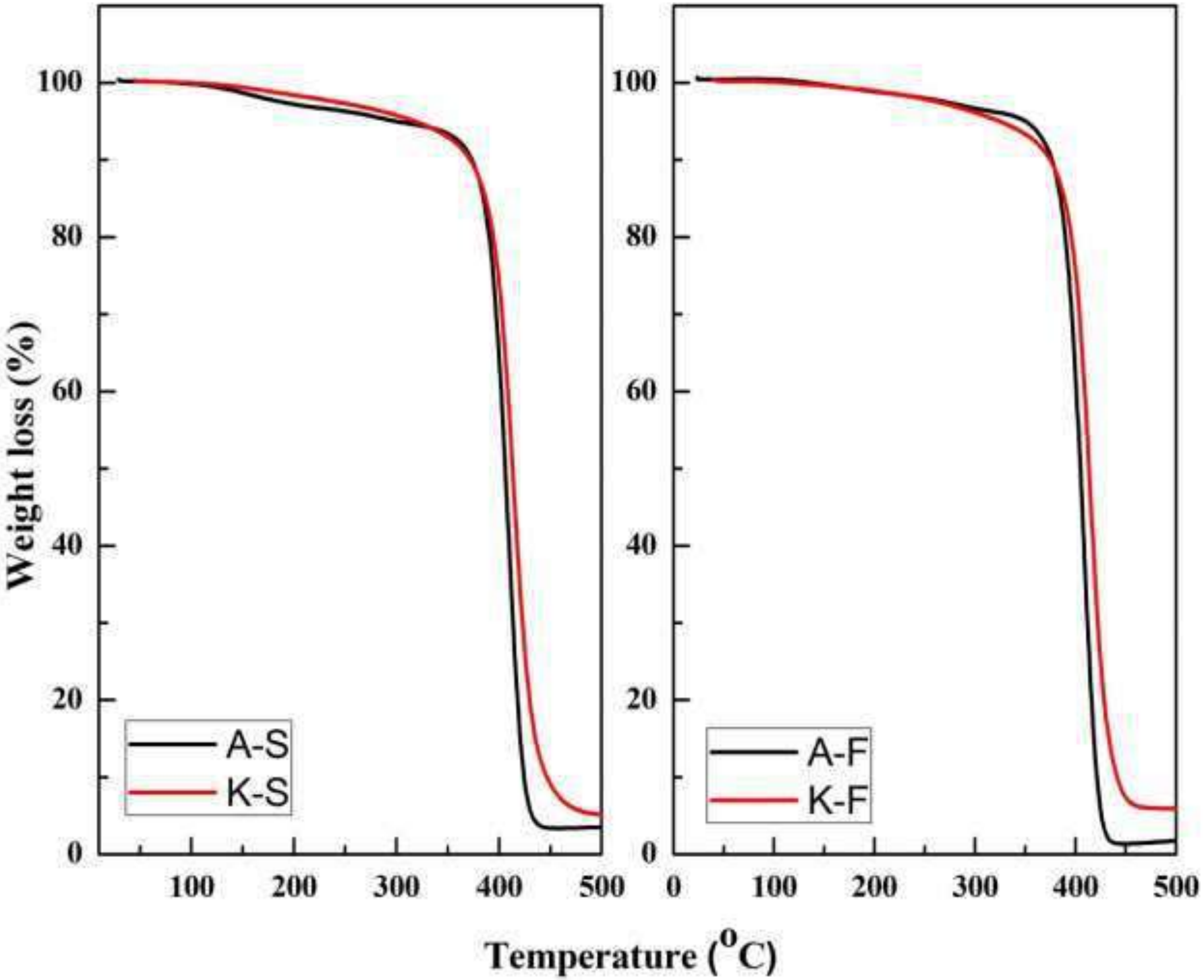

Figure 10. TGA curves of VTES and TFEMA-containing waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes

- ***Tests and measurements***

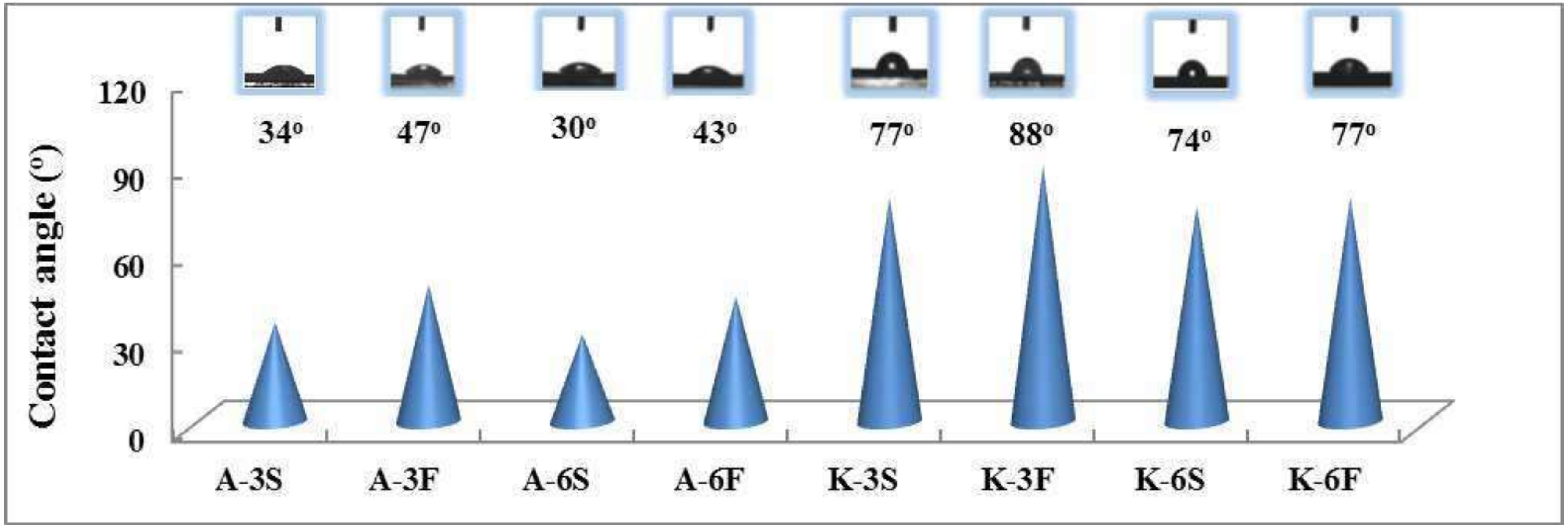

Figure 11. Static contact angle values of waterborne hydrophobic hybrid (alkyd/styrene acrylic) latexes containing VTES and TFEMA

The reaction was repeated for K-6S without AA. It has been observed that the contact angle of the obtained latex film increased (92°).

- ***Tests and measurements***

Table 3. Physicochemical properties of hydrophobic hybrid latexes

Emulsion Properties	SC(%)	pH	Visc (cP) (20°C)	T_g (°C)
A-3S	49.70	8.18	105	10
A-3F	50.70	8.12	104	17
A-6S	50.02	8.24	108	
A-6F	49.86	8.30	107	
K-3S	49.03	8.24	116	7
K-3F	49.42	8.28	120	10
K-6S	50.72	8.20	132	
K-6F	50.24	8.18	136	

SC: solid content; Visc: viscosity; T_g*; glass transition temperature*

Conclusion

- In this study, monomers containing silane and fluorine groups were successfully incorporated into the waterborne hybrid (alkyd/styrene acrylic) polymer latex system. The effects of these fluorine and silane agents on the physical and chemical properties of the functional coating materials were discussed.

- The synthesized waterborne hybrid latexes and films were characterized by FT-IR, NMR, particle size, zeta potential, gel content, AFM, STEM, EDAX, TGA, DSC, and CA tests. The structures of waterborne hybrid (alkyd/styrene acrylic) polymer latex modified with VTES and TFEMA synthesized from FT-IR and NMR results were confirmed.

- The tests (AFM, STEM, EDAX, CA, DSC, and TGA) showed that, in addition to the alkyd content, silane and fluorine groups also contribute positively to the synthesized films. We saw more clearly the advantages of fluorine and silane groups, especially in polymer emulsions containing alkyd (K-S; K-F).

- As a result, it is expected to obtain composite materials with advantages and to expand the application range with the modification of silane and fluorine agents in addition to the copolymerization of three materials with high complementarity (alkyd-styrene-acrylate).

- It could be suggested that these synthesized alkyd-based hybrid latexes will increase their potential as protective coatings.

Conclusion

- In addition, it is thought that the use of plant sources such as hemp seed oil in the synthesis of alkyd-based hybrid latex, in terms of sustainability and environmental friendliness, will form the basis for more reliable and healthy coating applications in the future.

Acknowledgments

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References

1. Kotlík, P, Doubravová, K, Horálek, J, Kubác, L and Akrman, J, ”Acrylic copolymer coatings for protection against UV rays.” Journal of Cultural Heritage, (2013). http://dx.doi.org/10.1016/j.culher.2013.01.002.

2. Grigsby, WJ, “Photooxidative stability provided by condensed tannin additives in acrylic-based surface coatings on exterior exposure.” Journal of Coatings Technology and Research, (2018). https://doi.org/10.1007/s11998-018-0086-z.

3. Zhang, F, Jing, C, Yan, Z, Ge, S, Liu, P, Maganti, S, Xu, BB, Mahmoud, KH, El-Bahy, ZM, Huang, M and Guo, Z, “Fluorinated acrylic monomer modified core-shell polyacrylate latex particles: Preparation, properties and characterizations.” Polymer, 247 124783 (2022). https://doi.org/10.1016/j.polymer.2022.124783.

4. Zhong, S, Qin, K, Hou, Y, Xu, T, Cai, Y and Yi, L, “Waterborne corrosion-resistant hydrophobic alkyd resin composite coatings modified with fluorinated acrylate–siloxane and submicron-sheet zinc phosphate pigment.” Journal of Coatings Technology and Research, 18 (5) 1309–1320 (2021). https://doi.org/10.1007/s11998-021-00493-x.

5. Yu, Z, Yan, Z, Zhang, F, Wang, J, Shao, Q, Murugadoss, V, Alhadhrami, A, Mersal, GAM, Ibrahim, MM, El-Bahy, ZM, Li, Y, Huang, M and Guo, Z, “Waterborne acrylic resin co-modified by itaconic acid and γ-methacryloxypropyl triisopropoxidesilane for improved mechanical properties, thermal stability, and corrosion resistance.” Progress in Organic Coatings, 168 106875 (2022). https://doi.org/10.1016/j.porgcoat.2022.106875.

6. Wang, G, Wen, S, Qian, S, Wang, J, Wang, C and Chen, Y, “Synthesis of novel nano hyperbranched polymer resin and its corrosion resistance in coatings.” Progress in Organic Coatings 140 105496 (2020). https://doi.org/10.1016/j.porgcoat.2019.105496.

7. Nanvaee, AA, Yahya, R and Gan, SN, “Alkyd Resins Are Still of Major Important Bınders In Organic Coatings.” Malaysia Polymer International Conference (2009).

8. Kausar, A, “Polymer coating technology for high performance applications: Fundamentals and advances.” Journal of macromolecular scıence, part a: pure and applıed chemistry, 1–9 (2018). https://doi.org/10.1080/10601325.2018.1453266.

9. Dong, W, Zhou, L, Guo, Y, Tang, Y, Pan, R, Liu, M and He, D, “Modification of styrene-acrylic emulsion by organic UV absorber in synergy with fluorine and silicon monomers for weatherable coatings.” Journal of Coatings Technology and Research, 19 (2) 607–616 (2022). https://doi.org/10.1007/s11998-021-00550-5.

10. Wang, P, Zhang, D and Lu, Z, “Advantage of super-hydrophobic surface as a barrier against atmospheric corrosion ınduced by salt deliquescence.” Corrosion Science, (2014). http://dx.doi.org/10.1016/j.corsci.2014.09.001.

11. Zheng, B, Ge, S, Wang, S, Shao, Q, Jiao, C, Liu, M, Das, R, Dong, B and Guo, Z, “Effect of γ-aminopropyltriethoxysilane on the properties of cellulose acetate butyrate modified acrylic waterborne coatings.” Reactive and Functional Polymers, 154 104657 (2020). https://doi.org/10.1016/j.reactfunctpolym.2020.104657.

12. Machotova, J, Černošková, E, Honzíček, J and Šňupárek, J, “Water sensitivity of fluorine-containing polyacrylate latex coatings: Effects of crosslinking and ambient drying conditions.” Progress in Organic Coatings, (2018). https://doi.org/10.1016/j.porgcoat.2018.03.016.

13. Zhang, P and Lv, FY, “A review of the recent advances in superhydrophobic surfaces and the emerging energy-related applications.” Energy, 1-20 (2015). http://dx.doi.org/10.1016/j.energy.2015.01.061.

14. Vazirinasab, E, Jafari, R and Momen, G, “Application of superhydrophobic coatings as a corrosion barrier: A review.” Surface & Coatings Technology, 341 40–56 (2018). https://doi.org/10.1016/j.surfcoat.2017.11.053.

References

15. Chardon, F, Denis, M, Negrell, C and Caillol, S, "Hybrid alkyds, the glowing route to reach cutting-edge properties?" Progress in Organic Coatings, 151 106025 (2021). https://doi.org/10.1016/j.porgcoat.2020.106025.
16. Huang, CM, Wang, HY, Fang, SY and Yang, WD, "Influence of fluorine-containing monomer content on the hydrophobic and transparent properties of nanohybrid silica polyacrylate coating materials." Materials 14 4261 (2021). https://doi.org/10.3390/ma14154261.
17. Bogdanowicz, KA, Dutkiewicz, M, Maciejewski, H, Nowicki, M, Przybył, W, Plebankiewicz, I and Iwan, A, "Siloxane resins as hydrophobic self-cleaning layers for silicon and dye-sensitized solar cells: material and application aspects." RSC Advances, 12 19154 (2022). https://doi.org/10.1039/d2ra02698h.
18. Kanai, T, Mahato, TK and Kumar, D, "Synthesis and characterization of novel silicone acrylate–soya alkyd resin as binder for long life exterior coatings." Progress in Organic Coatings, 58 259–264 (2007). https://doi.org/10.1016/j.porgcoat.2006.11.002.
19. Zhong, S, Li, J, Yi, L. Cai, Y and Zhou, W, "Cross-linked waterborne alkyd hybrid resin coatings modified by fluorinated acrylate-siloxane with high waterproof and anticorrosive performance." Polymers for Advanced Technologies, 30 292–303 (2019). https://doi.org/10.1002/pat.4464.
20. Huang, K, Liu, Y and Wu, D, "Synthesis and characterization of polyacrylate modifiedby polysiloxane latexes and films." Progress in Organic Coatings, 77 1774–1779 (2014). http://dx.doi.org/10.1016/j.porgcoat.2014.06.001.
21. Bao, Z, Li, W, Xu, T, Fu, Z and Chen, L, "Preparation and thermal stability of phosphorus acrylic latex modified with organic silicon." Journal of Polymer Materials, 32 (4) 483-490 (2015).
22. Lü, T, Qi, D, Zhang, D, Liu, Q and Zhao, H, "Fabrication of self-cross-linking fluorinated polyacrylate latex particles with core-shell structure and film properties." Reactive and Functional Polymers, 104 9–14 (2016). http://dx.doi.org/10.1016/j.reactfunctpolym.2016.04.020.
23. Zhao, H, Gao, L, Gao, S and Shi, J, "Synthesis and polymerization kinetics of copolymer styrenevinyltrimethoxysilane by emulsifier-free emulsion polymerization." Advanced Materials Research, 150-151 1537-1540 (2011). https://doi.org/10.4028/www.scientific.net/amr.150-151.1537.
24. Zhong, S, Li, J, Cai, Y and Yi, L, "Novel surfactant-free waterborne acrylic-silicone modified alkyd hybrid resin coatings containing nano-silica for the corrosion protection of carbon steel." Polymer-Plastics Technology and Materıals, 58 (8) 866–878 (2019). https://doi.org/10.1080/03602559.2018.1542711.
25. Gao, Y, Liu, S, Wang, Q and Wang, G, "Preparation of melamine–formaldehyde resin grafted by (3-aminopropyl) triethoxysilane for high-performance hydrophobic materials." Journal of Applied Polymer Science, 48664 1-10 (2019). https://doi.org/10.1002/app.48664.
26. Xu, Y, Li, M and Liu, M., "Corrosion and fouling behaviors of phosphatized Q235 carbon steel coated with fluorinated polysiloxane coating." Progress in Organic Coatings, 134 177–188 (2019). https://doi.org/10.1016/j.porgcoat.2019.04.079.
27. Zhu, B, Liu, Z, Liu, J, Yang, Y, Meng, Y, Yu, F, Jiang, L, Wei, G and Zhang, Z, "Preparation of fluorinated/silanized polyacrylates amphiphilic polymers and their anticorrosion and antifouling performance." Progress in Organic Coatings 140 105510 (2020). https://doi.org/10.1016/j.porgcoat.2019.105510.

References

28. Wu, Y, Zhu, C, Yanchen, Z, Qiu, H, Ma, H, Gao, C and Liu, Y, “A type of silicone modified styrene-acrylate latex for weatherable coatings with improved mechanical strength and anticorrosive properties.” Reactive and Functional Polymers, 148 104484 (2020). https://doi.org/10.1016/j.reactfunctpolym.2020.104484.

29. Wang, X, Cui, Y, Wang, Y, Ban, T, Zhang, Y, Zhang, J and Zhu, X, “Preparation and characteristics of crosslinked fluorinated acrylate modified waterborne polyurethane for metal protection coating.” Progress in Organic Coatings, 158 106371 (2021). https://doi.org/10.1016/j.porgcoat.2021.106371.

30. Wu, J, Wang, C, Lin, W and Ngai, T, “A facile and effective approach for the synthesis of fluorinated waterborne polyurethanes with good hydrophobicity and antifouling properties.” Progress in Organic Coatings, 159 106405 (2021). https://doi.org/10.1016/j.porgcoat.2021.106405.

31. Yilgör, E and Yilgör, İ, “Silicone containing copolymers: Synthesis, properties andapplications.” Progress in Polymer Science, 848 31 (2013). http://dx.doi.org/10.1016/j.progpolymsci.2013.11.003.

32. Jiang, W, Dai, A, Zhou, T and Xie, H, “Hybrid polysiloxane/polyacrylate/nano-SiO_2 emulsion for waterborne polyurethane coatings.” Polymer Testing, 80 106110 (2019). https://doi.org/10.1016/j.polymertesting.2019.106110.

33. Ifijen, IH, Odi, HD, Maliki, M, Omorogbe, SO, Aigbodion, AI and Ikhuoria, EU, "Correlative studies on the properties of rubber seed and soybean oil-based alkyd resins and their blends." Journal of Coatings Technology and Research, 18 (2) 459-467 (2021). https://doi.org/10.1007/s11998-020-00416-2.

34. Lyu, B, Li, X, Liu, H, Gao, D, Ma, J and Zhang, M, “Preparation of an amphiphilic Janus SiO2/fluorinated polyacrylate latex film and its application as a hydrophobic fabric agent.” Journal of Colloid and Interface Science, 599 88–99 (2021). https://doi.org/10.1016/j.jcis.2021.04.061.

35. Lei, H, He, D, Hu, J, Li, P and Huang, H, “A fluorine–silicone acrylic resin modified with UV-absorbing monomers and a free radical scavenger.” Journal of Coatings Technology and Research, (2018). https://doi.org/10.1007/s11998-018-0078-z.

36. Kartaloğlu, N, Akçin, SE, Eren, M and Delibaş, A, “Waterborne hybrid (alkyd/styrene acrylic) emulsion polymers and exterior paint applications.” Journal of Coatings Technology and Research, (2023). https://doi.org/10.1007/s11998-023-00767-6.

37. Yun, X, Xin-yi, Y, Dun-hong, G, Yong-bo, D and Liang, S, “Preparation and characterization of waterborne alkyd-amino baking coatings based on waste polyethylene terephthalate.” Royal Society Open Science, 7 191447 (2020). http://dx.doi.org/10.1098/rsos.191447.

38. Angın, N and Ertaş, M, “Farklı çözücü türlerinin ekstraksiyon reçinesinin verimi ve kimyasal özellikleri üzerine etkisi.” Turkish Journal of Forestry, 22 (4) 439-443 (2021). https://doi.org/10.18182/tjf.960674.

39. Saravari, O, Phapant, P and Pimpan, V, "Synthesis of water-reducible acrylic–alkyd resins based on modified palm oil." Journal of Applied Polymer Science, 96 (4) 1170-1175 (2005). https://doi.org/10.1002/app.21009.

40.Muhammad, A, Abbas, S, Shafeeq, A, Al-Turaif, HA, Taimoor, AA, Ali, AM and Deshannavar, UB, "Synthesis and Characterization of Pentaerythritol Phthalic Anhydride Resin from Soybean Oil." Asian Journal of Chemistry, 30 572-574 (2018).

References

41. Hadzich, A, Gross, GA, Leimbach, M, Ispas, A, Bund, A and Flores, S, "Characterization of Plukenetia volubilis L. fatty acid-based alkyd resins." Polymer Testing, 82 106296 (2020). http://dx.doi.org/10.1016/j.polymertesting.2019.106296.
42. Assanvo, EF, Gogoi, P, Dolui, SK and Baruah, SD, "Synthesis, characterization, and performance characteristics of alkyd resins based on Ricinodendron heudelotii oil and their blending with epoxy resins." Industrial Crops and Products, 65 293-302 (2015). http://dx.doi.org/10.1016/j.indcrop.2014.11.049.
43. Tiwari, S, Saxena, M and Tiwari, S, "Preparation and Characterization of Penta Alkyds Based on Mahua Oil." Journal of Scientific & Industrial Research, 61 110-116 (2002).
44. Li, H, Zhou, J, Zhao, J, Li, Y and Lu, K, "Synthesis of cellulose nanocrystals-armored fluorinated polyacrylate latexes via Pickering emulsion polymerization and their film properties." Colloids and Surfaces B: Biointerfaces, 192 111071 (2020). https://doi.org/10.1016/j.colsurfb.2020.111071.
45. He, S, Liu, W, Yang, M, Liu, C, Jiang, C and Wang, Z, "Fluorinated polyacrylates containing amino side chains for the surface modification of waterborne epoxy resin." Journal of Applied Polymer Science, (2018). https://doi.org/10.1002/APP.47091.
46. Irska, I, Paszkiewicz, S, Goracy, K, Linares, A, Ezquerra, TA, Jedrzejewski, R, Rosłaniec, Z and Piesowicz, E, "Poly(butylene terephthalate)/polylactic acid based copolyesters and blends: miscibility-structure-property relationship." Express Polymer Letters, 14 (1) 26–47 (2020). https://doi.org/10.3144/expresspolymlett.2020.
47. Goikoetxea, M, Reyes, Y, de las Heras Alarcón, CM, Minari, RJ, Beristain, I, Paulis, M, Barandiaran, MJ, Keddie, JL and Asua, JM, "Transformation of waterborne hybrid polymer particles into films: Morphology development and modeling." Polymer, 53 (5) 1098-1108 (2012). https://doi.org/10.1016/j.polymer.2012.01.021.
48. Limousin, E, González, E, Martínez-Tong, DE, Ballard, N and Asua, JM, "Modelling the dynamic development of the curing process and film morphology of films cast from waterborne acrylic-alkyd hybrids." Chemical Engineering Journal, 400 125891 (2020).
49. El-Gholabzouri, O, Cabrerizo-Vílchez, MA and Hidalgo-Alvarez, R, "Zeta-potential of polystyrene latex determined using different electrokinetic techniques in binary liquid mixtures." Colloids and Surfaces A: Physicochemical and Engineering Aspects, 291 (1-3) 30–37 (2006). https://doi.org/10.1016/j.colsurfa.2006.05.017.
50. García-Salinas, MJ, Romero-Cano, MS and Nieves, FJ, "Zeta potential study of a polystyrene latex with variable surface charge: influence on the electroviscous coefficient. Trends in Colloid and Interface Science, 115 112–116 (2000). https://doi.org/10.1007/3-540-46545-6_23.
51. Yousefi, AA, Pishvaei, M and Yousefi, A, "Preparation of Water-Based Alkyd/Acrylic Hybrid Resins." Progress in Color, Colorants and Coatings, 4 (1) 15-25 (2011)
52. Wei, Z, Ling, H, Junyan, L, Gang, C and Na, W, "Preparation and properties of core–shell nanosilica/poly(methyl methacrylate–butyl acrylate–2,2,2-trifluoroethyl methacrylate) latex." Journal of Applied Polymer Science, 120 (2) 1152-1161 (2011). https://doi.org/ 10.1002/app.
53. Wu, XQ, Schork, FJ and Gooch, JW, "Hybrid miniemulsion polymerization of acrylic/alkyd systems and characterization of the resulting polymers." Journal of Polymer Science Part A: Polymer Chemistry, 37 (22) 4159-4168 (1999).
54. Eduok, U, Faye, O and Szpunar, J, "Recent developments and applications of protective silicone coatings: A review of PDMS functional materials." Progress in Organic Coatings, 111 124–163 (2017). http://dx.doi.org/10.1016/j.porgcoat.2017.05.012.

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