2020 IMAGINENANO ONLINE SEPT 29 – OCT 01, 2020

Bringing together Nanoscience & Nanotechnology

POLYMERIC NANOPARTICLE DISPERSIONS BASED ON SUSTAINABLE ALTERNATIVE COSOLVENTS TO NMP

Lorena Germán[a], José María Cuevas[a]; José Luis Vilas Vilela[b]

[a] Gaiker Technology Centre, Basque Research and Technology Alliance (BRTA)

[b] Departamento de Química Física, University of the Basque Country (UPV/EHU)

Background

Aqueous polymeric nanodispersions are real alternative to reduce volatile organic compounds emissions in coatings and adhesive products. Aqueous polyurethane dispersions (PUD) have particular importance due to their similar performance to conventional solvent borne products[1]. The fabrication process requires an organic solvent in order to reduce the viscosity during polymer synthesis and allow coalescence of nanoparticles and film formation[2], see figure1.

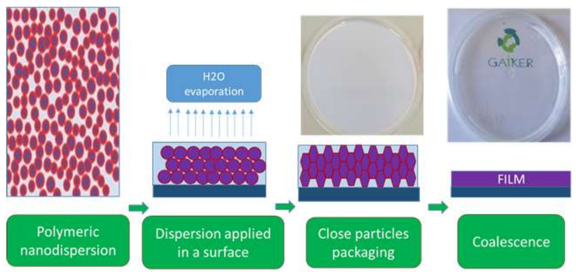


Figure 1. Diagram Film Forming

At industrial scale the solvent with better balance between performance and price is N-methylpyrrolidone (NMP). However the use of this chemical has been restricted by European Union EU2018/588 [4]. This study is focused on finding sustainable alternative cosolvent for NMP in PUD material.

Results

Solvent has a key role in PUD, it must fulfil important requirements: isocyanate inert, good solvent capacity, water miscible, high boiling point, etc In this study NMP and three green alternative solvents have been used to synthesize PUDs (DP_NMP, DP_1, DP_2 and DP_3) in order to get aqueous polyurethane nanodispersion with low toxicity and low carbon footprint[5][6], see table 1.

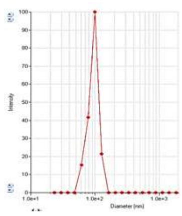
Table1. Scoring outcomes for solvents studied according to GKS´s solvent sustainability guide.[7].

SOLVENT	Boiling point(ºC)	Incineration	Recycling	Biotreatment	Aquatic impact	Air impact	Health Hazard	Exposure potential	Reactivity &Stability
NMP	202	3	4	3	10	6	1	9	9
1	203	4	4	5	9	6	4	8	10
2	207	8	7	10	10	6	4	8	10
3	242	4	5	6	10	10	10	10	10

The dispersions obtained have been analysed and compared. According to DLS results samples present monomodal distribution and a d50 <100nm, table 2.

Table 2. Results of particle size distribution and Z potential of nanodispersions

	DP_NMP	DP_1	DP_2	DP_3
Polydispersity	0,13	0,13	0,13	0,15
Diam. 10 (nm)	60,27	27,74	26,88	57,51
Diam. 50 (nm)	**93,57**	**43,32**	**42,30**	**92,14**
Diam. 90 (nm)	145,36	67,68	66,59	147,73
Z potential mV	-44,83	-38,61	-38,45	-48,98



Nanodispersions are electrostatically stable according to Z potential results and this behaviour is permanent during at least 1 month, see figure 2.

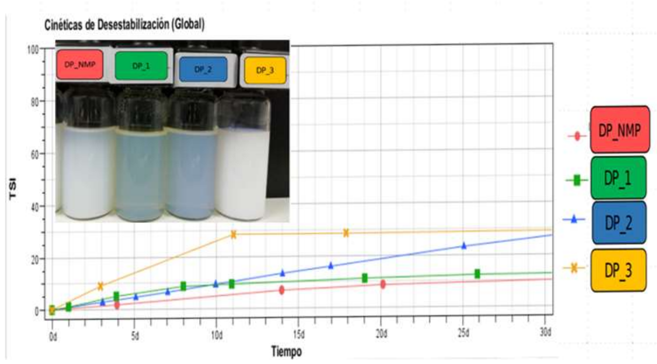


Figure 2. Nanodispersions photograph and graphic of destabilization kinetics

The molecular weight of the polyurethanes obtained was found to be similar, independently of using conventional or green solvents, see figure 3.

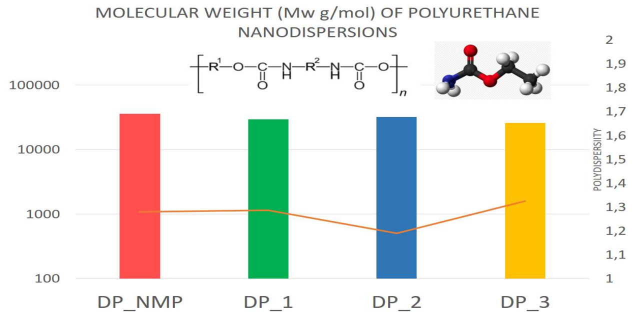


Figure 3. Molecular weight graphic of PUD dispersions

Conclusions

According with all results obtained, the three alternatives to NMP studied are very promising for obtaining less toxic and more sustainable aqueous polyurethane dispersions. However, further studies and researches are needed in order to validate these new sustainable solvents as substitutes of NMP in polyurethane nanodispersion systems.

Acknowledgments

The authors acknowledge the financial support from Spanish Government in the frame of RETOS program, (RTC-2017-6385-5) and thank CROMOGENIA UNITS for technical and time support on the project. This work has also been supported by the biobased Industries Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under VIPRISCAR project grant agreement No 790440. The JU receives support form the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium.

CONTACT PERSON

Lorena Germán
Fundación Gaiker

Email: german@gaiker.es

REFERENCES

[1]H. W. Engels *et al.*, *Angew. Chemie - Int. Ed.*, vol. 52, no. 36, pp. 9422–9441, 2013.
[2]L. A. Felton, *Int. J. Pharm.*, vol. 457, no. 2, pp. 423–427, 2013.
[3]J. K. Oh, J. Anderson, B. Erdem, R. Drumright, and G. Meyers, 2016.
[4]The Europian Commission, *Off. Jounal Eur. Union*, vol. 1, no. 1272, pp. 16–19, 2018.
[5]D. Prat *et al.*, *Green Chem.*, vol. 18, no. 1, pp. 288–296, 2015.
[6]F. P. Byrne *et al.*, *Sustain. Chem. Process.*, vol. 4, no. 1, pp. 1–24,2016.
[7]C. M. Alder *et al.*, *Green Chem.*, vol. 18, no. 13, pp. 3879–3890, 2016.

2020 IMAGINENANO ONLINE