

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 1, July 2022

A Review on Bigel Novel Drug Delivery System

Saher Naaz Binfazur Salim Chous¹, Dr. Mohammad Ismail Mouzam², Quadri Mohammed Soheb Abdul Khalique³, Ansari Vikhar Danish Ahmed⁴

Department of Quality Assurance, YB. Chavan College of Pharmacy, Dr Rafique Zakaria Campus, Aurangabad. India¹ Department of Pharmaceutics, Y. B. Chavan College of Pharmacy, Dr Rafique Zakaria Campus, Aurangabad. India² Department of Pharmaceutics, Mangaldeep Institute of Pharmacy, Nipani, Aurangabad. India³ Department of Pharmacology, Y. B. Chavan College of Pharmacy, Dr. Rafique Zakaria Campus, Aurangabad. India⁴

Abstract: Bigels are systems that are usually formed by mixing a hydrogel and an organogel: the aqueous phase is generally made of hydrophilic biopolymer through the organic phase comprise of a gelled vegetable oil because of the presence of an organogelator. The quantity of the gelling agent in every phase, the organogel/ hydrogel percentage, and the temperature of mixing and speed of each parameter need to be considered for bigel preparation. Bigels are chiefly beneficial drug delivery systems, which have been prepared for transdermal, buccal, and vaginal routes. Analytical studies and microscopical determination are the most reported characterization techniques. Bigel's composition and distinguishing structure confer promising drug delivery aspects such as mucoadhesion, the capability to control drug release, and the probability of using both hydrophilic and lipophilic drugs in the same system.

Keywords: Hydrogel, oleogel, bigel, organogel, organogelators.

REFERENCES

- [1]. V.K. Singh, I. Banerjee, T. Agarwal, K. Pramanik, M.K. Bhattacharya, K. Pal, "Guar gum and sesame oil based novel bigels for controlled drug delivery," Colloids Surf B Biointerfaces, vol. 123, 582–592,2014.
- [2]. V.K. Singh, A. Anis, I. Banerjee, K. Pramanik, M.K. Bhattacharya, K. Pal, "Preparation and characterization of novel carbopol based bigels for topical delivery of metronidazole for the treatment of bacterial vaginosis," Mater Sci Eng C. vol. 44,151–158, 2014.
- [3]. H. Alsaab, S.P. Bonam, D. Bahl, P. Chowdhury, K. Alexander, S.H. Boddu, "Organogels in drug delivery: a special emphasis on pluronic lecithin organogels," J Pharm Pharm Sci. vol. 19, 252, 2016.
- [4]. A. Vintiloiu, J.-C. Leroux, "Organogels and their use in drug delivery a review," J.-Control Release, vol. 125, 179–192, 2008.
- [5]. M.M. Ibrahim, S.A. Hafez, M.M. Mahdy, "Organogels, hydrogels, and bigels as transdermal delivery systems for diltiazem hydrochloride," Asian J Pharm Sci, vol. 8 (1), 48–57, 2013.
- [6]. S.S. Sagiri, V.K. Singh, S. Kulanthaivel, I. Banerjee, P. Basak, M.K. Battarchrya, et al., "Stearate organogelgelatin hydrogel based bigels: Physicochemical, thermal, mechanical characterizations and in vitro drug delivery applications," J Mech Behav Biomed Mater, vol. 43, 1–17, 2015
- [7]. C.L. Esposito, P. Kirilov, V.G. Roullin, "Organogels, promising drug delivery systems: an update of state-ofthe-art and recent applications," J Control Release, vol. 271, 1–20,2018.
- [8]. F.R. Lupi, A. Shakeel, V. Greco, C. Oliviero Rossi, N. Baldino, D. Gabriele, "A rheological and microstructural characterization of bigels for cosmetic and pharmaceutical uses," Mater Sci Eng C, vol. 69, 358–365,2016.
- [9]. A. Shakeel, U. Farooq, T. Iqbal, S. Yasin, F.R. Lupi, D. Gabriele, "Key characteristics and modeling of bigels systems: a review," Mater Sci Eng C., vol. 97, 932–953,2019.
- [10]. K. Rehman, M.C.I. Mohd Amin, M.H. Zulfikar, "Development and physical characterization of polymer-fish oil bigel (hydrogel/oleogel) system as a transdermal drug delivery vehicle," J Oleo Sci, vol. 63, 961–970, 2014.
- [11]. V. Andonova, P. Peneva, G.S. Georgiev, V.T. Toncheva, E. Apostolova, Z. Peychev, et al., "Ketoprofenloaded polymer carriers in bigel formulation: An approach to enhancing drug photostability in topical application forms," Int J Nanomedicine, vol. 12, 6221–6238, 2017.



International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 1, July 2022

- [12]. F.R. Lupi, L. Gentile, D. Gabriele, S. Mazzulla, N. Baldino, B. de Cindio, "Olive oil and hyperthermal water bigels for cosmetic uses," J Colloid Interface Sci, vol. 459, 70–78, 2015.
- [13]. Fekete T, Borsa J. "polysaccharide-based polymer gels. In: Polymer Gels," Gels Horizons: Sciences to Smart Materials, Vol. 1., Ch. 5. Singapore; Springer; p. 147-8,2018
- [14]. Lin HR, Hsu CY, Lo YL. "Preparation and characterization of dual phase transition oral hydrogel for sustained release of epirubicin," Int J Polymer Biomater, vol. 62:763-9, 2013.
- [15]. Rehman K, Zulfikar MH, "Recent advances in gel technologies for topical and transdermal drug delivery," Drug Dev Ind Pharm, vol. 40, 433-40, 2014.
- [16]. D. Golodnizky, M. Davidovich-Pinhas, "The effect of the HLB value of sucrose ester on physiochemical properties of bigel systems," Foods, vol. 9, 1857, 2020.
- [17]. A.J. Martins, P. Silva, F. Maciel, L.M. Pastrana, R. Lopes Cunha, M.A. Cerqueria, et al., "Hybrid gels: influence of oleogel/hydrogel ratio on rheological and textural properties," Food Res Int, vol. 116, 1298–1305, 2019.
- [18]. Z. Hu, X. Zhang, Y. Li, "Synthesis and application of modulated polymer gels," Science, vol. 80, 525– 527,1995.
- [19]. G.J. Rhee, J.S. Woo, S.-J. Hwang, Y.W. Lee, C.H. Lee, "Topical oleo-hydrogel preparation of ketoprofen with enhanced skin permeability," Drug Dev Ind Pharm, vol. 25 (6), 717–726, 1999.
- [20]. I.F. Almeida, A.R. Fernandes, L. Fernandes, M.R. Pena Ferreira, P.C. Costa, M.F. Bahia, "Moisturizing effect of oleogel/hydrogel mixtures," Pharm Dev Technol, vol. 13 (6), 487–494, 2008.
- [21]. M. Ivaskiene, A. Mazurkeviciute, K. Ramanauskiene, M. Ivaskiene, A. Grigonis, V. Briedis, "Topical antifungal bigels: Formulation, characterization and evaluation," Acta Pharm, vol. 68 (2), 223–233, 2018.
- [22]. D.S. Lima, E.T. Tenório-Neto, M.K. Lima-Tenório, M.R. Guilherme, D.B. Scariot, C.V. Nakamura, et al., "pH-responsive alginate-based hydrogels for protein delivery," J Mol Liq, vol. 262, 29–36, 2018.
- [23]. N.A. Peppas, "Hydrogels and drug delivery," Curr Opin Colloid Interface Sci, vol. 2 (5), 531–537, 1997.
- [24]. B. Tomadoni, C. Casalongué, V.A. àlvarez, "biopolymer-based hydrogels for agriculture applications: swelling behavior and slow release of agrochemicals," in: T.J. Gutiérrez (Ed.), Polymers for Agri-Food Applications pp. 99–126, 2019.
- [25]. E.M. Ahmed, "Hydrogel: Preparation, characterization, and applications: a review," J Adv Res, vol. 6 (2), 105–121, 2015.
- [26]. D. Kolodynska, A. Skiba, B. Gorecka, Z. Hubicki, "Hydrogels from fundaments to application," in S. Biswas Majee (Ed.), Emerging Concepts in Analysis and Applications of Hydrogels, London; IntechOpen, pp. 69– 100, 2016.
- [27]. H. Shivakumar, C. Satish, K. Satish, "Hydrogels as controlled drug delivery systems: synthesis, crosslinking, water and drug transport mechanism," Indian J Pharm Sci, vol. 68 (2), 133, 2006.
- [28]. L.h. Yahia, "History and applications of hydrogels, J Biomed Sci, vol.4 (2), 1–13, 2015.
- [29]. H. Wang, S.C. Heilshorn, "Adaptable hydrogel networks with reversible linkages for tissue engineering," Adv Mater, vol. 27 (25), 3717–3736, 2015.
- [30]. V.K. Yadav, A.B. Gupta, R. Kumar, J.S. Yadav, B. Kumar, "Mucoadhesive polymers: means of improving the mucoadhesive properties of drug delivery system," J Chem Pharm Res, vol. 2 (5), 418–432, 2010.
- [31]. B. Saraswathi, A. Balaji, M.S. Umashankar, "Polymers in mucoadhesive drug delivery system-latest updates," Int J Pharm Pharm Sci, vol. 5, 423–430. 2013.
- [32]. S. Roy, K. Pal, A. Anis, K. Pramanik, B. Prabhakar, "Polymers in mucoadhesive drug-delivery systems: a brief note," Des Monomers Polym, vol. 12 (6), 483–495, 2009.
- [33]. J. Smart, "The basics and underlying mechanisms of mucoadhesion," Adv Drug Deliv Rev. vol. 57 (11), 1556–1568, 2005.
- [34]. A. Lohani, G. Chaudhary, "Mucoadhesive microspheres: a novel approach to increase gastroprotection," Chronicles Young Sci, vol. 3 (2), 121, 2012.
- [35]. Z.-Q. Cao, G.-J. Wang, "Multi-stimuli-responsive polymer materials: particles, films, and bulk gels," Chem



Volume 2, Issue 1, July 2022

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Rec. vol. 16 (3), 1398-1435, 2016.

- [36]. S. Bazban-Shotorbani, M.M. Hasani-Sadrabadi, A. Karkhaneh, V. Serpooshan, K.Jacob, A. Moshaverinia, et al., "Revisiting structure-property relationship of pH- responsive polymers for drug delivery applications," J Control Release, vol. 253, 46–63, 2017.
- [37]. J. Brady, T. Dürig, P.I. Lee, J.-X. Li, Y. Qiu, Y. Chen, G.G.Z. Zhang, L. Yu, R.V. Mantri, "Polymer properties and characterization, Developing Solid Oral Dosage Forms," Elsevier, pp. 181–223, 2017.
- [38]. V.Y. Andonova, P.T. Peneva, E.G. Apostolova, T.D. Dimcheva, Z.L. Peychev, M.I.Kassarova, "Carbopol hydrogel/sorbitan monostearate–almond oil based organogel biphasic formulations: preparation and characterization of the bigels," Trop J Pharm Res, vol. 16 (7), 1455, 2017.
- [39]. K. Rehman, M.F.F. Mohd Aluwi, K. Rullah, L.K. Wai, M.C.I. Mohd Amin, M.H. Zulfakar, et al., "Probing the effects of fish oil on the delivery and inflammation- inducing potential of imiquimod," Int J Pharm, vol. 490 (1–2) 131–141, 2015.
- [40]. M.H. Zulfakar, L.M. Chan, K. Rehman, L.K. Wai, C.M. Heard, "Coenzyme Q10-loaded fish oil-based bigel system: probing the delivery across porcine skin and possible interaction with fish oil fatty acids," AAPS PharmSciTech, vol. 19 (3), 1116–1123,2018.
- [41]. K. Rehman, M.H. Zulfakar, "Novel fish oil-based bigel system for controlled drug delivery and its influence on immunomodulatory activity of imiquimod against skin cancer," Pharm Res, vol. 34 (1), 36–48, 2017.
- [42]. R. Hamed, N.N. Mahmoud, S.H. Alnadi, A.Z. Alkilani, G. Hussein, "Diclofenac diethylamine nanosystemsloaded bigels for topical delivery: development, rheological characterization, and release studies," Drug Dev Ind Pharm, vol. 46 (10), 1705–1715, 2020.
- [43]. E. Algin Yapar, S. Tuncay Tanriverdi, G. Aybar Tural, Z.P. Gümü, S. E. Turunç, E.H.Gokce, "An examination of carbopol hydrogel/organogel bigels of thymoquinone prepared by microwave irradiation method," Drug Dev Ind Pharm, 46 (10), (2020) 1639–1646, 2020.
- [44]. J. Kanoujia, P.P. Nikita, N. Singh, S.A. Saraf, "Tea tree and jojoba oils enriched bigel loaded with isotretinoin for effective management of acne," Indian J Nat Prod Resour, vol. 12 (1), 158–163, 2021.
- [45]. R. Hamed, A. AbuRezeq, O. Tarawneh, "Development of hydrogels, oleogels, and bigels as local drug delivery systems for periodontitis," Drug Dev Ind Pharm, vol. 44 (9), 1488–1497, 2018.
- [46]. A. Viridén, A. Larsson, S. Abrahmsén-Alami, D. Caccavo, A.A. Barba, G. Lamberti, "Effects of HPMC substituent pattern on water up-take, polymer and drug release: an experimental and modeling study," Int J Pharm, vol. 528(1–2), 705–713, 2017.
- [47]. Martín-Illana, F. Notario-Pérez, R. Cazorla-Luna, R. Ruiz-Caro, M.D. Veiga, "Smart freeze-dried bigels for the prevention of the sexual transmission of HIV by accelerating the vaginal release of tenofovir during intercourse," Pharmaceutics, vol. 11 (5), 232, 2019.
- [48]. R.N. Charyulu, A. Muaralidharan, D. Sandeep, "Design and evaluation of bigels containing flurbiprofen," Res J Pharm Technol, vol. 11 (1), 143, 2018.
- [49]. S. Mukherjee, S. Majee, G.R. Biswas, "Formulation and in vitro characterization of soybean oil-HPMCK4M based bigel matrix for topical drug delivery," Int J Appl Pharm, vol. 11, 33–38, 2019.
- [50]. Khelifi, M. Saada, E.A. Hayouni, A. Tourette, J. Bouajila, R. Ksouri, "Development and characterization of novel bigel-based 1,4-naphthoquinones for topical application with antioxidant potential," Arab J Sci Eng, vol. 45 (1), 53–61, 2020.
- [51]. M. Wróblewska, E. Szyman'ska, M. Szekalska, K. Winnicka, "Different types of gel carriers as metronidazole delivery systems to the oral mucosa," Polymers (Basel), vol. 12 (3), 680, 2020.
- [52]. Kariduraganavar MY, Kittur AA, Kamble RR, "Polymer synthesis and processing," Natural and Synthetic Biomedical Polymers, Amsterdam; Elsevier; 1–31, 2014.
- [53]. S. Satapathy, V.K. Singh, S.S. Sagiri, T. Agarwal, I. Banerjee, M.K. Battacharya, et al., "Development and characterization of gelatin-based hydrogels, emulsion hydrogels, and bigels: a comparative study," J Appl Polym Sci, vol. 132 (8), 41502, 2015.
- [54]. S. Wakhet, V.K. Singh, S. Sahoo, S.S. Sagiri, S. Kulanthaivel, M.K. Battacharya, et al., "Characterization of gelatin-agar based phase separated hydrogel, emulgel and bigel: a comparative study," J Mater Sci Mater



Volume 2, Issue 1, July 2022

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Med, vol. 26 (2), 118, 2015.

- [55]. A.M. Pegg, "The application of natural hydrocolloids to foods and beverages, in D. Baines, R. Seal (Eds.), Natural Food Additives, Ingredients and Flavourings," Woodhead Publishing, Sawston, pp. 175–196, 2012.
- [56]. V.K. Singh, A. Anis, S.M. Al-Zahrani, D.K. Pradhan, K. Pal, "FTIR, Electrochemical impedance and iontophoretic delivery analysis of guar gum and sesame oil based bigels," Int J Electrochem Sci, 9, 5640– 5650, 2014.
- [57]. H. Roy, S. Maddela, A. Munagala, S.A. Rahaman, S. Nandi, "A quality by design approach of metronidazole bigel and assessment of antimicrobial study utilizing Box-Behnken design," Comb Chem High Throughput Screen, 24 (10) 1628–1643, 2021.
- [58]. A. Martín-Illana, R. Cazorla-Luna, F. Notario-Pérez, L.M. Bedoya, R. Ruiz-Caro, M.D. Veiga, "Freeze-dried bioadhesive vaginal bigels for controlled release of Tenofovir," Eur J Pharm Sci, vol. 127, 38–51, 2019
- [59]. P. Sriamornsak, N. Wattanakorn, H. Takeuchi, "Study on the mucoadhesion mechanism of pectin by atomic force microscopy and mucin-particle method," Carbohydr Polym, vol. 79 (1), 54–59, 2010.
- [60]. A.A. Sundar Raj, S. Rubila, R. Jayabalan, T.V. Ranganathan, "A review on pectin: chemistry due to general properties of pectin and its pharmaceutical uses," Open Access Sci Reports, vol. 1 (12), 550–553, 2012.
- [61]. F.R. Lupi, M.P. De Santo, F. Ciuchi, N. Baldino, D. Gabriele, "A rheological modeling and microscopic analysis of bigels," Rheol Acta, vol. 56 (9) 753–763, 2017.
- [62]. Behera, S. Dey, V. Sharma, K. Pal, "Rheological and viscoelastic properties of novel sunflower oil-span 40biopolymer-based bigels and their role as a functional material in the delivery of antimicrobial agents," Adv Polym Technol, vol. 34 (2), 21488, 2015.
- [63]. M.O. Ilomuanya, A.T. Hameedat, E.N. Akang, S.O. Ekama, B.O. Silva, A.S. Akanmu, "Development and evaluation of mucoadhesive bigel containing tenofovir and maraviroc for HIV prophylaxis," Futur J Pharm Sci, vol. 6 (1) 81, 2020.
- [64]. B. Singh, R. Kumar, "Designing biocompatible sterile organogel-bigel formulations for drug delivery applications using a green protocol," New J Chem, vol. 43 (7), 3059–3070, 2019.
- [65]. S.R. Paul, D. Qureshi, Y. Yogalakshmi, S.K. Nayak, V.K. Singh, I. Syed, et al., "Development of bigels based on stearic acid-rice bran oil oleogels and tamarind gum hydrogels for controlled delivery applications," J Surfactants Deterg, vol. 21 (1), 17–29, 2018.
- [66]. M.A. Bollom, S. Clark, N.C. Acevedo, "Development and characterization of a novel soy lecithin-stearic acid and whey protein concentrate bigel system for potential edible applications," Food Hydrocoll, vol. 101, 105570, 2020.
- [67]. Behera, V.K. Singh, S. Kulanthaivel, M.K. Bhattacharya, K. Paramanik, I. Banerjee, et al., "Physical and mechanical properties of sunflower oil and synthetic polymers based bigels for the delivery of nitroimidazole antibiotic – a therapeutic approach for controlled drug delivery," Eur Polym J, vol. 64, 253–264, 2015.
- **[68].** R.M. Martinez, W.V. Magalhães, S.B. da Silva, G. Padovani, L.I. Sbrugnera Nazato, M.V. Robles Velasco, et al., "Vitamin E-loaded bigels and emulsions: Physicochemical characterization and potential biological application," Colloids Surfaces Biointerfaces, vol. 201, 111651, 2021.
- [69]. Nigar Kadar Mujawar SLG and VCY, "Organogel: factors and its importance," Int J Pharm Chem Biol Sci, vol. 4(3): 758–773, 2014.
- [70]. S. Sahoo, N. Kumar, C. Bhattacharya, S.S. Sagiri, K. Jain, K. Pal, et al., "Organogels: properties and applications in drug delivery," Des Monomers Polym, vol. 14 (2), 95–108, 2011.
- [71]. S.S. Sagiri, B. Behera, R.R. Rafanan, C. Bhattacharya, K. Pal, I. Banjerjee, et al., "Organogels as matrices for controlled drug delivery: a review on the current state," Soft Matter, vol. 12 (1), 47–72, 2014.
- [72]. G. Tarun, B. Ajay, K. Bhawana, K.R.J. Sunil, "Organogels: advanced and novel drug delivery system," Int Res J Pharm, vol. 2 (12), 15–21, 2011.
- [73]. M. Suzuki, K. Hanabusa, "Polymer organogelators that make supramolecular organogels through physical cross-linking and self-assembly," Chem Soc Rev, vol. 39 (2), 455–463, 2010.
- [74]. Genot, T.-H. Kabri, A. Meynier, C. Jacobsen, N. Skall Nielsen, A. Frisenfeldt Horn, A. D. Moltke Sørensen, "Stabilization of omega-3 oils and enriched, Sawston; Woodhead Publishing, pp. 150–193, 2013.



International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 1, July 2022

- [75]. S. Murdan, G. Gregoriadis, A.T. Florence, "Novel sorbitan monostearate organogels," J Pharm Sci, vol. 88 (6), 608–614, 1999.
- [76]. B. Behera, S.S. Sagiri, K. Pal, K. Pramanik, U.A. Rana, I. Shakir, et al., "Sunflower oil and protein-based novel bigels as matrices for drug delivery applications— characterization and in vitro antimicrobial efficiency," Polym Plast Technol Eng, vol. 54 (8), 837–850, 2015.
- [77]. Behera B, Singh VK, Kulanthaivel S, Bhattacharya MK, Paramanik K, Banerjee I, et al. "Physical and mechanical properties of sunflower oil and synthetic polymers based bigels for the delivery of nitroimidazole antibiotic-a therapeutic approach for controlled drug delivery," Eur Polym J, vol. 64:253-64, 2015.
- [78]. Lupi FR, Shakeel A, Greco V, Rossi CO, Baldino N, Gabriele D, "A rheological and microstructural characterization of bigels for cosmetic and pharmaceutical uses," Mater Sci Eng C, vol. 69, 358-65, 2016.
- [79]. Singh V, Banerjee I, Agarwal T, Pramanik K, Bhattacharya MK, Pal K, "Guar gum and sesame oil based novel bigels for controlled drug delivery," Colloid Surf B Biointerfaces, vol. 123:582-92, 2014.
- [80]. Lupi FR, Gentile L, Gabriele D, Mazzulla S, Baldino N, De Cindio B, "Olive oil and hyperthermal water bigels for cosmetic uses," J Colloid Interf Sci, vol. 459:70-8, 2015.
- [81]. Fekete T, Borsa J. "polysaccharide-based polymer gels. In: Polymer Gels, Gels Horizons" Sciences to Smart Materials, vol. 1, Ch. 5. Singapore; Springer; p. 147-8, 2018.
- [82]. Lin HR, Hsu CY, Lo YL, "Preparation and characterization of dual phase transition oral hydrogel for sustained release of epirubicin," Int J Polym Biomater, vol. 62,763-9, 2013.
- [83]. Rehman K, Zulfakar MH, "Recent advances in gel technologies for topical and transdermal drug delivery," Drug Dev Ind Pharm, vol. 40, 433-40, 2014.
- [84]. Otto W, Drahoslav L. "Hydrophilic gels in biologic use," Nature, vol. 185, 117-8, 1960
- [85]. Seiler GJ, Gulya TJ. "Sunflower: overview," In Smithers G, ed. Reference Module in Food Science. Elsevier; 2016.
- [86]. Lupi FR, Shakeel A, Greco V, Baldino N, Calabro V, Gabriele D, "Organogelation of extra virgin olive oil with fatty alcohols, glyceryl stearate, and their mixture," LWT Food Sci Technol, vol. 77:422-9, 2017.
- [87]. Lupi FR, Gabriele D, Greco V, Baldino N, Seta L, De Cindio B, "A rheological characterization of an olive oil/fatty alcohols organogel," Food Res Int, vol. 51, 510-7, 2013.
- [88]. Ogutcu M, Yılmaz E, "Characterization of hazelnut oil oleogels prepared with sunflower and carnauba waxes," Int J Food Prop, vol. 18, 1741-55, 2015.
- [89]. Bollom MA, Clark S, Acevedo NC, "Development and characterization of a novel soy lecithin-stearic acid and whey protein concentrate bigel system for potential edible applications," Food Hydrocolloids, vol. 101:1055-70, 2020.
- [90]. Schaink HM, Van Malssen KF, Morgado-Alves S, Kalnin D, Van der Linden E, "Crystal network for edible oil organogels: Possibilities and limitations of the fatty acid and fatty alcohol systems," Food Res Int, vol. 40, 1185-93, 2007.
- [91]. Kumar R, Katare OP, "Lecithin organogels as a potential phospholipid- structured system for topical drug delivery: A review," AAPS Pharm SciTech, vol. 6, 298-310, 2005.
- [92]. Dassanayake LS, Kodali DR, Ueno S, Sato K, "Physical properties of rice bran wax in bulk and organogels," J Am Oil Chem Soc, vol. 86, 1163, 2009.
- [93]. Mallia VA, George M, Blair DL, Weiss RG, "Robust organogels from nitrogen-containing derivatives of (R)-12-hydroxystearic acid as gelators: Comparisons with gels from stearic acid derivatives," Langmuir, vol. 25, 8615-25, 2009.
- [94]. Suzuki M, Nanbu M, Yumoto M, Shirai H, Hanabusa K, "Novel dumbbell- form low-molecular-weight gelators based on L-lysine: Their hydrogenation and organogelation properties," New J Chem, vol. 29, 1439-44, 2005.
- [95]. Shakeel A, Farooq U, Gabriele D, Marangoni AG, Lupi FR, "Bigels and multi-component organogels: An overview from rheological perspective," Food Hydrocolloids, vol. 10, 1061-90, 2020.
- [96]. Wassén S, Bordes R, Gebäck T, Bernin D, Schuster E, Lorén N, et al, "Probe diffusion in phase-separated bicontinuous biopolymer gels," Soft Matter, vol. 10, 8276-87, 2014.

IJARSCT



International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 1, July 2022

- [97]. Yu G, Yan X, Han C, Huang F, "Characterization of supramolecular gels," Chem Soc Rev, vol. 42 6697-722, 2013.
- [98]. Singh VK, Anis A, Banerjee I, Pramanik K, Bhattacharya MK, Pal K, "Preparation and characterization of novel carbopol based bigels for topical delivery of metronidazole for the treatment of bacterial vaginosis," Mater Sci Eng C, vol. 44, 151-8, 2014.
- [99]. Rehman K, Amin MC, Zulfakar MH, "Development and physical characterization of polymer-fish oil bigel (hydrogel/oleogel) system as a transdermal drug delivery vehicle," J Oleo Sci, 14101, 2014.
- [100]. Sreekumar M, Mathan S, Mathew SS, Dharan SS, "Bigels: An updated review," J Pharm Sci Res, vol. 12, 1306-8, 2020.
- [101]. Souza RL, Faria E, Figueiredo R, Fricks, "A Use of polyethylene glycol in the process of sol-gel encapsulation of Burkholderia cepacia lipase," J Therm Anal Calorimetry, vol. 117, 301-6, 2014.
- [102]. Singh VK, Sagiri SS, Pal K, Khade SM, Pradhan DK, Bhattacharya MK, "Gelatin-carbohydrate phaseseparated hydrogels as bioactive carriers in vaginal delivery: preparation and physical characterizations," J Appl Polym Sci, vol. 131, 40445, 2014.
- [103]. Behera B, Sagiri SS, Singh VK, Pal K, Anis A, "Mechanical properties and delivery of drug/probiotics from starch and non-starch based novel bigels: A comparative study," Starch-Stärke, vol. 66, 865-79, 2014.
- [104]. Behera B, Dey S, Sharma V, Pal K, "Rheological and viscoelastic properties of novel sunflower oil-span 40biopolymer based bigels and their role as a functional material in the delivery of antimicrobial agents, Adv Polym Tech, vol. 34, 21488, 2015.
- [105]. Sahoo S, Sing VK, Biswal D, Anis A, Rana UA, Al-Zahrani S, et al, "Development of ionic and non-ionic natural gum-based bigels: Prospects for drug delivery application," J Appl Polym Sci, vol. 132, 42561, 2015.
- [106]. Ibrahim MM, Hafez SA, Mahdy MM, "Organogels, hydrogels, and bigels as transdermal delivery systems for diltiazem hydrochloride," Asian J Pharm Sci, vol. 8, 48-57, 2013.
- [107]. Satapathy S, Singh VK, Sagiri SS, Agarwal T, Banerjee I, Bhattacharya MK, et al, "Development and characterization of gelatin- based hydrogels, emulsion hydrogels, and bigels: A comparative study" J Appl Polym Sci, vol. 132, 41502, 2015.
- [108]. Singh VK, Anis A, Al-Zahrani S, Pradhan DK, Pal K, "Molecular and electrochemical impedance spectroscopic characterization of the carbopol based bigel and its application in iontophoretic delivery of antimicrobials," Int J Electrochem Sci, vol. 9, 5049-60, 2014.
- [109]. Wakhet S, Singh VK, Sahoo S, Sagiri SS, Kulanthaivel S, Bhattacharya MK, et al, "Characterization of gelatin–agar based phase separated hydrogel, emulgel and bigel: A comparative study," J Mater Sci Mater Med, vol. 26, pp 118, 2015.
- [110]. Rehman K, Zulfakar MH, "Novel fish oil-based bigel system for controlled drug delivery and its influence on the immune modulatory activity of imiquimod against skin cancer," Pharm Res, vol. 34, 36-48, 2017.
- [111]. Andonova VY, Peneva PT, Apostolova EG, Dimcheva TD, Peychev ZL, Kassarova MI, "Carbopol hydrogel/sorbitan monostearate- almond oil based organogel biphasic formulations: Preparation and characterization of the bigels," Trop J Pharm Res, vol. 16, 1455-63, 2017.
- [112]. Velichka A, Petya P, George SG, Vencislava TT, "Ketoprofen loaded polymer carriers in bigel formulation: An approach to enhancing drug photostability in topical application forms," Int J Nanomed, vol. 12, 6221-38, 2017.