

Impact case study (REF3)

Institution: University of Bristol		
Unit of Assessment: 8) Chemistry		
Title of case study: Bristol and Snow Business co-create eco-friendly artificial snow and reduce environmental impact of film and TV industries		
Period when the underpinning research was undertaken: 2008 - 2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Wuge Briscoe	Reader in Physical Chemistry	2008 - present
Period when the claimed impact occurred: 2016 - 2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact

Snow Business, the world's largest supplier of artificial snow for TV, films, stage and events, recognized in 2014 market opportunities for a radically new snow product that was non-toxic and left no harmful residues. They teamed up with the Briscoe group at the University of Bristol, using their expertise in Soft Matter, to propose two new eco-friendly artificial snow products. These world-leading products have now been used in over 1,200 events since 2017, including dozens of blockbuster Hollywood films, major festivals, shows and TV programmes. In 2019, Snow Business obtained the only BAFTA-supported environmental certification of their products for use in film and TV, strengthening their international position as the predominant global supplier of eco-friendly artificial falling snow. In 2019, the UK film production sector generated a total spend of over GBP1.95 billion, a contribution which is growing annually at 17% more than three times the rate of the wider UK economy. Use of soft matter expertise developed in Bristol has increased employment and turnover in a local SME and generated a step change in the environmental impact of this significant and rapidly growing sector of the UK economy.

2. Underpinning research

Research in the Soft Matter at Interfaces group at the University of Bristol led by Briscoe focuses on molecular interactions between polymers, surfactants, and nanoparticles which regulate the interfacial structures of soft matter systems such as foams, thin films, and lipid multilayers. The UoB group has deployed powerful quantitative analytical techniques, such as neutron reflectivity to unravel the composition and structure of interfacial surfactant-polymer complexes [1], atomic force microscopy to probe surface nano-morphologies [2], and direct force measurements of interactions between surface layers [3], as well as synchrotron X-ray reflectivity using the "bending mica" method unique to Bristol [4] to provide structural details of soft nanofilms. Research at Bristol has led to fundamental new insights into:

- the surface interactions mediated by confined surfactant thin films [4, 5].
- interfacial structures and properties of a broad range of soft matter systems, such as lipid bilayers [4, 6] and hierarchical polymer networks [6].
- the mechanisms by which the molecular architecture of surfactants and polymers can be tailored for desired interfacial properties [1, 3].

Working with world-leading international companies such as P&G, GSK, Infineum, and Alkermes the Briscoe group has developed considerable expertise in designing and quantitatively analysing

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the stability of thin liquid films using eco-friendly ingredients, addressing in particular how foams form and how long they hold their shape. The UoB group used this expertise to evaluate potential multicomponent systems relevant to Snow Business' formulations. Static and dynamic interfacial tension, conductivity, and the thickness and molecular packing in interfacial layers, were correlated with macroscopic phenomenological parameters to characterise product performance. The combination of the fundamental insights and unique experimental capabilities at Bristol enabled several key scientific challenges to be addressed:

- (i) In choosing individual eco-friendly surfactants for evaluation as less harmful replacements, the Bristol team were able to quickly converge on a small number of promising candidates, ensuring that their architectures satisfied the molecular packing and activity in the self-assembled structures in the solution and at the air-water interface. This sped up considerably the initial formulation design.
- (ii) In assessing the compatibility and synergy between eco-friendly surfactants and other formulation additives, the team were able to pinpoint the active ingredients and design measurements based on their interactions predicted using thermodynamic models. This allowed a focused experimental approach, significantly reducing the number of measurements, saving time and resources.
- (iii) In optimising the formulation, the team were able to evaluate the foamability and foam stability using laboratory-based methods to correctly predict product performance. This informed product formulation and scale-up, significantly reducing the cost and time.

3. References to the research

- [1] Slastanova A, Campbell RA, Snow T, Mould E, Li P, Welbourn RJL, Chen M, Robles R, **Briscoe WH**. (2020). Synergy, competition, and the "hanging" polymer layer: Interactions between a neutral amphiphilic 'tardigrade' comb co-polymer with an anionic surfactant at the air-water interface, *J. Coll. Interf. Sci.*, 561, 181. DOI:[10.1016/j.jcis.2019.11.017](https://doi.org/10.1016/j.jcis.2019.11.017)
- [2] Quignon B, Pilkington GA, Thormann E, Claesson PM, Ashfold MNR, Mattia D, Leese H, Davis SA. & **Briscoe WH**. (2013). Sustained Frictional Instabilities on Nanodomed Surfaces: Stick–Slip Amplitude Coefficient. *ACS Nano*, 7, 10850-10862. DOI:[10.1021/nn404276p](https://doi.org/10.1021/nn404276p)
- [3] Chen M, **Briscoe WH**, Armes SP, & Klein J. (2009). Lubrication at Physiological Pressures by Polyzwitterionic Brushes. *Science*, 323, 1698-1701. DOI:[10.1126/science.1169399](https://doi.org/10.1126/science.1169399)
- [4] Speranza F, Pilkington GA, Dane TG, Cresswell PT, Li PX, Jacobs RMJ, Arnold T, Bouchenoire L, Thomas RK. & **Briscoe WH**. (2013). Quiescent bilayers at the mica-water interface. *Soft Matter*, 9, 7028-7041. DOI:[10.1039/C3SM50336D](https://doi.org/10.1039/C3SM50336D)
- [5] **Briscoe WH**. (2017). Aqueous boundary lubrication: Molecular mechanisms, design criteria, and terra incognita. *Cur. Opin. Coll. Interf. Sci.* 27, 1, DOI:[10.1016/j.cocis.2016.09.002](https://doi.org/10.1016/j.cocis.2016.09.002)
- [6] Wlodek M, Kolasinska-Sojka M, Szuwarzynski M, Kereiche S, Kovacic L, Zhou L, Islas L, Warszynski P, **Briscoe WH**. (2018). Supported lipid bilayers with encapsulated quantum dots (QDs) via liposome fusion: Effect of QD size on bilayer formation and structure", *Nanoscale* 10, 17965-17974. DOI:[10.1039/C8NR05877F](https://doi.org/10.1039/C8NR05877F)

4. Details of the impact

Co-creation of a novel eco-friendly falling snow formulation

Snow Business (SB), located in Stroud 30 miles from Bristol, is the world's leading supplier of artificial snow for TV, films and stage and exhibition sets. Prior to 2016, their most effective snow fluid was based on petrochemical ingredients. Consequently, the snow effect it generated could cause respiratory discomfort for cast and crew on film sets and left behind residues that could be harmful to the surroundings and sensitive plant and animal life. SB recognized the market potential for a new eco-friendly alternative but being a relatively small company (34 employees and an annual turnover of about GBP5.5 million, in 2019), it lacked suitable research capabilities [A].

To address this challenge, Snow Business approached Briscoe, because of his proven expertise in soft matter [A], to design an eco-friendly falling snow formulation which could be applied in a wide range of scene settings used by Hollywood film productions. A collaborative research program was developed, co-funded by an EPSRC Impact Acceleration Award and SB. Briscoe with the help of a MSc student, Lizzie Mould, used their fundamental knowledge and experimental expertise to create clusters of stabilised air bubbles surrounded by μm -thick interfacial water films to achieve the visual effect of falling snow. The stability of the bubbles could be tuned so that they burst and diminished on demand. The collaboration resulted in two unique falling snow products, EcoFlake and ProFlake™ tailored to the film production and event industries, winning the Best Research & Development Project in the Engineering, Manufacturing and Innovation (EMI) Awards in the Cotswolds from a strong field [B]. Paul Denney, Head of Research and Development at SB, in an interview with the BBC said:

"We had looked at developing the product ourselves but the chemistry involved was beyond our capabilities, which is why we approached the University of Bristol." "We weren't totally sure what Lizzie would be able to do, especially as we had a long wish list of characteristics, but she's really come up trumps and surpassed all our expectations." [Ci].

Environmental credentials ensure wide-spread adoption within film and TV industries

The artificial snow products developed jointly by Snow Business and the Bristol team are the most environmentally friendly snow fluid currently on the market. The development helped SB in 2019 become the only snow product business to gain an Albert certificate of sustainability (widely respected in the Film industry) [Di]. ProFlake and EcoFlake are currently the only certified sustainable falling snow products endorsed by the British Academy of Film and Television Arts (BAFTA) [Di] and have been used widely in film, TV and music productions. To date these materials have been used in over 1,200 productions including [A, E]:

- Movies such as *Wonder Woman*, *Christopher Robin*, *The Current War*, *Nutcracker and the Four Realms*, *Murder on the Orient Express*, *Last Christmas*, *The Aeronauts*, and *Emma*.
- Leading TV series including *Dr Who Doctor*, *Victoria*, *Call the Midwife*, *A Christmas Carol* and *Casualty*.
- Music videos by *Robbie Williams*, and *Kylie Minogue*.
- Festivals and events including *VW festival*, *Glastonbury*, *Greenpeace*, *Arcadia's Metamorphosis*, *CenterParcs Christmas*.
- Christmas adverts for McDonalds, Matalan, and John Lewis, as well as photography for Burberry, Easyjet and Monsoon.

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These products, and their world-leading certification of sustainability, have provided Snow Business with “first mover” advantage, with the new products taking 90% of the world market for environmentally friendly falling snow effects. SB’s annual sales figures increased by over 40,000 litres with these products and turnover increased by GBP124,800 (80%) in fluid sales [A]. The company has taken on one new research staff to service the business (significant in terms of the company’s size of 34 employees) and their partner manufacturer instigated expanded operations for the new products and the machinery used to deploy them [A]. The fluid has proven to have other uses in addition to snow effects, which could open up new business markets. For example, it was used in wind turbine testing conducted jointly by Stanford University and California Institute of Technology in a fragile desert ecosystem which required a fluid with high environmental credentials [F]. The development of the eco-friendly falling snow attracted considerable media coverage (e.g. BBC News [Ci and Cii] and various local radio shows) and was also highlighted by the EPSRC Pioneer magazine ([Gii]), raising public consciousness of environmental issues [H, I].

Staging environmentally sustainable public events

Falling snow special effects have traditionally not been used in public events due to harmful residues and respiratory discomfort from petrochemical-based formulations. The new eco-snow products are a game-changer, enabling environmentally sustainable events to be held, which would not have been previously possible. [B]. The growing list of SB customers includes [Glastonbury Festival](#), Stroud High School, Stroud City Council, various film/TV production companies (BBC, ITV), and English Heritage [Eiv]. Below we give a couple of examples [A, E]:

Glastonbury and Arcadia – Dancing in the falling snow

Festivals are often renowned for their damage to the local environment. One of the most spectacular features of the Glastonbury Festivals are the light, sound and pyrotechnic shows of Arcadia. An emphasis on the environment led the Arcadia team to come up with a brand-new look for the 2018 show, namely a snow blast [Eii]. SB’s falling snow was first used in their touring Metamorphosis show and has become a core feature of their brand-new Pangea show at Glastonbury 2019. *“The snow effect has been a long collaboration between us, Bristol University, Green Peace and a company called Snow Business,”* stated Cole, Co-Founder and Technical Director for Arcadia [Ei]. *“We were looking at other effects we could use to take over the sky. Confetti was always a no-go due to the impact on the environment. The snow blasts didn’t have this problem and were 100% safe for people and the surrounding wildlife.”* [Ei]. The environmental credentials of the snow formulation products were crucial to meeting the high sustainability and eco requirements of both Arcadia and the Glastonbury organisers.



Arcadia at the 2019 Glastonbury Festival

Christmas At Eden

In 2014, the Eden project approached SB with the idea of making it snow inside one of the biggest tropical biomes in the world without *“the risk of damage to their unique collection of tropical plants, or the delicate soil they grow in”*. Real snow, being very cold, would damage tender tropical plants and would be dangerous, expensive and technically challenging in tropical temperatures. No snow fluid was available with sufficient environmental credentials to pass Eden’s strict requirements. *“Christmas looked to be on-hold.”* [Eiii].



760 litres of Eco-Flake solution were used to transfer the Eden main dome into a giant tropical snow globe at the Christmas.

In 2016 with the joint development by UoB and SB of eco-friendly snow formulations “A series of tests were conducted over several weeks, including germination of plants in soil watered with our solution. The results were analysed, and after 3 weeks, the lead fluid, EcoFlake, passed the biological tests. That Christmas.....the main dome of the Eden project was temporarily turned into a giant tropical snow globe....” [Eiii].

5. Sources to corroborate the impact

- [A] Snow Business (31/03/2020). Supporting Letter - Head of Research at Snow Business; see also <https://www.snowbusiness.com/>
- [B] Cotswold Life (27/10/2020). [Cotswold Life Engineering Manufacturing and Innovation Awards Winners 2016](#)
- [C] i) BBC News (14/07/2016). [Bristol chemistry student creates ‘greenest’ fake snow](#)
 ii) BBC News, Bristol (14/07/2016). Video: [Student’s green snow for silver screen](#)
- [D] i) Albert (2020). Snow Business is an [Albert Sustainable Productions Registered Supplier](#)
For background to the Albert scheme see <http://wearealbert.org/>
 ii) Albert (2020). [2019-20 Annual Report](#)
- [E] i) Issuu (2019). [Glastonbury 2019 Highlights](#)
 ii) Snow Business (2018). Video: Snow as used by Arcadia
 iii) Snow Business (2020). Case Study: [Christmas at Eden](#)
 iv) Snow Business (2020). [Our Work Latest News](#)
- [F] Wei *et al.* (2020). Near-Wake structure of full-scale vertical axis wind turbines, Available at: <https://arxiv.org/abs/1912.10106>
- [G] i) EPSRC Case Study: [Artificial snow research opens path to Hollywood](#)
 ii) EPSRC Pioneer Magazine - Innovation Special [Pushing the boundaries of innovation](#)
Circulated to all UK universities and thousands of UK and international researchers registered with EPSRC (p.14-15)
 iii) EPSRC [The Physical Sciences. Why they matter](#) – Snowflakes (p.14)
- [H] UoB (2016). i) Press release: [Bristol ‘snow’ to premiere in Hollywood and beyond](#)
 ii) Online impact story: [Making ‘snow’ greener](#)
 iii) Business and partnerships: [Snow Business](#)
- [I] UoB (2017). [Category winners to be honoured in Vice-Chancellor’s Impact Awards](#)
Business and Economy category