2013

ADVANCING THE SEPARATION SCIENCES THROUGH THE DELIVERY OF NEW MATERIALS, TECHNOLOGY AND METHODOLOGY.

Brett Paull

PHD

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Award date:
2013

Awarding institution:
University of Plymouth

ADVANCING THE SEPARATION SCIENCES THROUGH THE DELIVERY OF NEW MATERIALS, TECHNOLOGY AND METHODOLOGY.

By

Brett Paull

A thesis and collection of works submitted to Plymouth University in partial fulfilment for the degree of

DOCTOR OF SCIENCE

Faculty of Science and Technology

July 2013

Author's Declaration

At no time during the registration for the degree of Doctor of Science has the author been registered for any other University award without prior agreement of the Graduate Committee.

Work submitted for this research degree at Plymouth University has not formed part of any other degree, either at Plymouth University or at any other establishment.

Brett Paull

23-07-2013

Acknowledgements

The collection of works presented here was only possible through the dedication and support of a great many talented and dedicated researchers, working for me, with me and around me, over the past twenty years. It to all these wonderful students and colleagues I must say thank you.

Advancing the Separation Sciences Throughthe Delivery of New Materials, Technology and Methodology.

Brett Paull B.Sc. (Hons), Ph.D. (Plym), F.R.S.C., C.Chem.

Nature and Significance of the Work Submitted

Separation science is a multi-faceted discipline, underpinning almost all other fields of science and technology. Its scope encompasses fundamental and cutting edge processes and technologies, based upon exploitation of the physical distribution of chemical and biochemical species between solid, liquid or gaseous 'phases', facilitating their separation, purification, and analysis. Separation science plays a particularly pivotal element within the majority of modern analytical methods, methods which continue to support all manner of cutting edge scientific endeavour, including, for example, the current *'-Omics'* scientific revolution.

As inferred above, separation science can of course vary considerably in physical form and scale, from micro-extraction, to bench-top chromatographic methods, to large scale industrial process isolation and preparative systems. However, in each and every case there exists several common factors governing success, perhaps the most significant of which is so-called '*phase selectivity*', or the fundamental chemical and biochemical interaction between a molecularly defined/controlled surface or phase, and the individual target or group of molecules. On the laboratory and analytical scale, this interaction takes place within those phase materials routinely used in all modes of solid phase extraction (SPE) and chromatographic separations. Taking the example of one of the most commonly utilised pieces of laboratory analytical instrumentation (today found in almost all chemical, biochemical, clinical and industrial laboratories), namely the high-performance liquid chromatograph (HPLC), this all important *phase selectivity* comes from the incorporated chromatographic column, within which this molecularly defined/controlled surface or phase is housed.

Over the past two decades, as witnessed by the publications submitted for consideration herein, my research has focussed upon the understanding, control and exploitation of the various interactions between solutes and functionalised surfaces, to develop new chromatographic phases, separation selectivity and ultimately, new methods and chromatographic technology. Early on in this endeavour, the focus specifically lay in the interaction of metal ions with complexing ligands, either within solution (sample matrix or mobile phase), or through interaction with ligands immobilised upon modified stationary phase materials, either dynamically coated or covalently bound [25, 31, 34]. During this period, the research effort was instrumental in helping establish an entirely new mode of high-performance liquid chromatography for the separation of metal ions, namely *high-performance chelation ion chromatography* (HPCIC), a technology which has only recently fully come of age through the publication of a dedicated monograph on the technique, collaboratively compiled by three of its original developers [156].

Through-out the middle to late 1990s, the selective interactions of metal ions with metallochromic ligands, both for control of chromatographic selectivity and as a means of sensitive detection, was explored, in some cases simultaneously through the application of new 'colour-forming eluents' [5, 21]. These specific metal-ligand systems were later developed and exploited in various chromatographic modes, including ion chromatography [20], capillary electrophoresis [16],and reversed-phase liquid chromatography [23].

In the field of liquid chromatography, the two main aspirational goals of ever increasing peak capacity and resolution, and decreasing chromatographic run times, are diametrically opposed when using current technology. My research began in the early 2000's to take a fresh look at ion chromatography and push the limits of analysis time whilst maintaining reasonable peak capacity. The research led to the recognition of 'fast' ion chromatography as a possibility for many applications, and demonstrated sub-minute chromatography of inorganic anions or cations was readily achievable [30, 33]. This avenue of research quickly bought my group into the path of monolithic materials, which have remained a sub-theme within our research over the entire subsequent period [37]. Early attention focused upon the production and characterisation of a range of new monolithic anion and cation exchangers, based primarily on silica monolithic supports. The extension of this work into monolithic chelating ion exchangers soon followed, and the unique physical properties of the modified phases developed were exploited to develop new

chromatographic modes [51], such as 'low pressure' ion chromatography [45], and so-called 'solvent enhanced' ion chromatography [56]. The surface modification of monolithic materials with a new range of zwitterionic coatings, both in standard chromatography format and within micro-fluidic systems, also created new possibilities, one of which led to the development of 'double-gradient' ion chromatography [49].

Much of the above work on monolithic materials focused upon silica based materials, with a move into the development of polymer based monoliths taking place soon after. Here, many successes in the production of photo-grafted polymer monoliths for ion exchange and bio-separations were achieved [95], with new materials and formats reported, including new titanium housed monoliths for small molecule separations [103], nano-particle agglomerated monoliths (most recently applied to lectin affinity extraction) [102, 115] , and segmented/gradient stationary phases produced using photo-masking with UV polymerisation [101]. In the pursuit of these targets, new column characterisation techniques needed to be developed, which resulted in the development of several new detection technologies, including scanning capacitively coupled contactless conductivity (sC^{4}D) [62, 74], a technique now commonly utilised by most researchers developing capillary scale monolithic columns.

The coupling of analytical chemistry and instrumental development has also been a long standing theme within my research. New detection technologies have been developed and applied within chromatographic systems, such as the production of a new wide-bore C^{4}D detector [82], paired emitter-detector diode (PEDD) based absorbance detectors [87], novel deep UV LED based detection systems for capillary electrophoresis [36] and a single point C^{4}D, photometric and fluorimetric detector for capillary systems [100]. More recently, a number of additional instruments have been developed for polymer monolith production; including a Peltier array column heater for segmented thermal control [118] and most recently an automated UV oven for controlled production of photo-polymerised open tubular monolithic phases (MonoPLOT columns) [121].

One of the over-riding roles for an analytical scientist is to develop tools and technology for the better understanding of complex systems. Within our research we have enjoyed this challenge and provided new methods and approaches to the characterisation of numerous complex matrices. Over the years these have included ultra-trace analysis of environmental samples, including trace metals in seawater and industrial wastewaters [18],

determination of metals in industrial brines [9], quantitation of trace organic contaminants in potable and treated wastewaters (such as disinfection by-products (DBPs) or pharmaceutical and personal care products (PPCPs) [60, 105], and more recently, the analysis of industrial fermentation broths for monitoring of small bio-molecules [107].

In summary, the above body of work represents approximately 18 years of post-PhD research, centred upon advancing the separation sciences through the delivery of new materials, technology and methodology. The work is presented in 131 peer reviewed, high ranking analytical science journal articles, having attracted to-date close to 2000 citations. This work has also been presented, in various formats, over 300 times at national and international symposium and conferences.

Personal Contribution to the Work Submitted

For each and every journal article submitted herein as supporting material for the award of a Doctor of Science (D.Sc.) degree, I have provided significant and essential input at each of the planning, experimental, interpretation and publication stages. I am either first or corresponding author on ~70% of the publications listed, and for each publication where my name appears as the final author, I have acted as project supervisor.Indeed, for the vast majority (>80%) of the papers presented, I have been engaged as the primary supervisor of at least one of the postgraduate or postdoctoral researchers listed as co-authors, and as co-supervisor for the majority of the remaining 20% of work. I have published co-authored works with 138 post-graduate, post-doctoral, industrial and academic researchers in total, based within 1 of 28 separate Institutions. As the bulk of the published research submitted has been carried out by researchers from within my research group, I have attached (Appendix 1) at the end of this collection a full list of completed Ph.D. and M.Sc. students working under my primary or co-supervision for the period 1996 to 2012.

From within this body of work, the following ten typical articles have been selected to collectively supportthis submission, with my particular contribution to the research highlighted below each.

1 Wasim Bashir and Brett Paull, "***Determination of trace alkaline earth metals in brines using chelation ion chromatography with an iminodiacetic acid bonded silica column***", *Journal of Chromatography A*, 2001, 907, 191-200.

This 2001 publication, co-authored with my first primary supervised Ph.D student (W. Bashir), explored the selectivity and efficiency of IDA modified silica gel for trace analysis of metal ions in complex and industrially relevant matrices. It added strength to the emerging recognition of high-performance chelation ion chromatography as a new mode of ion chromatography and began work on a series of following papers on IDA (and IDA analogues) bonded silica which continues to the current time [131].

Ownership of the research reported within this paper lies primarily (>70%) with B. Paull.

2 Damian Connolly and Brett Paull, "***Fast ion chromatography of common inorganic anions on a short ODS column permanently coated with didodecyldimethylammonium bromide***", *Journal of Chromatography A*, 2002, 953, 299.

This early communication paper began a series of work on the development of so-called 'fast ion chromatography', changing the mind-set on what was possible with modern chromatographic phases in regard to small ion separations. The work, carried out as part of a supervised Ph.D.project (D. Connolly), was pivotal in a number of research groups internationally exploring this new potential, including the switch from particles to monolithic phases for ion chromatographic separations.

Ownership of the research reported within this paper lies primarily (>60%) with B. Paull.

3 EdelSugrue,Pavel N. Nesterenkoand Brett Paull, "***Iminodiacetic acid functionalised monolithic silica chelating ion exchanger for rapid determination of alkaline earth metal ions in high ionic strength samples***", *The Analyst*, 2003, 128, 417-420.

This early communication was the first to report upon bonded silica monoliths for the fast ion-exchange separations of metal ions. The work highlighted to the chromatographic community the potential of bonded silica monolithic phases for application other than normal- or reversed-phase separations. The work, carried out as part of the Ph.D. project of my student, EdelSugrue, began a series of projects on the application of such phases, and was key to later work exploring the switch from silica to polymer monolith phases for ion chromatographic separation of metal ions.

Ownership of the research reported within this paper lies primarily (>60%) with B. Paull.

4 D. Victory, P. Nesterenko and B. Paull, "***Low-pressure gradient micro-ion chromatography with ultra-short monolithic anion exchange column***", *The Analyst*, 2004, 129, 700-701.

This short communication, carried out as part of an M.Sc. project under my supervision (D. Victory), reported upon the first demonstration of what was to become so-called 'low-pressure ion chromatography'. The developed micro-ion chromatograph was applied to the separation of inorganic ions, based upon a low pressure short monolithic phase, of only 1 cm in length. This work went on to be developed further, with its significance still leading to collaborative research between the chromatographic and flow analysis research communities, and applications of low pressure ion chromatography in in-situ monitoring applications.

Ownership of the research reported within this paper lies primarily (>60%) with B. Paull.

5 Jonathan Bones,Kevin V. Thomasand Brett Paull, "***Using environmental analytical data to estimate levels of community consumption of illicit drugs and abused pharmaceuticals***", *Journal of Environmental Monitoring*, 2007, 9, 701-707.

This well cited analytical study into the use of wastewater samples for environmental epidemiology and societal drug use estimation attracted considerable international researcher and media interest.The work went on to initiate international collaborative projects on environmental epidemiology and drug use studies. The study was a topical application of new separation technology carried out as part of the research project of my Ph.D. student (J. Bones). The work was later developed further in projects looking at fate of such compounds within environmental matrices, leading to further well cited papers in this field [78, 88].

Ownership of the research reported within this paper lies primarily (>50%) with B. Paull.

6 Fu-QiangNie,Mirek Mackaand Brett Paull, "***Micro-flow injection analysis system: On-chip sample preconcentration, injection and delivery using coupled monolithic electroosmotic pumps***", *Lab-on-a-chip*, 2007, 7, 1597-1599.

This paper, published within the leading international micro-fluidics journal, demonstrated for the first time the controlled application of monolithic silica based electro-osmotic pumps within a micro-fluidic platform. The work, carried out by my post-doctoral researcher (F-Q. Nie), was a unique application of encased monolithic silica rods within the micro-fluidic manifold, which allowed the development of a micro-fluidic flow injection analysis manifold, with combined monolithic pump and solute concentration capability. The work demonstrated the potential of combining the chromatographic (materials) and analytical micro-fluidic research areas.

Ownership of the research reported within this paper lies primarily (>50%) with B. Paull.

7 David Collins, Ekaterina P. Nesterenko, Damian Connolly, Mercedes Vasquez, Mirek Macka, Dermot Brabazon, Brett Paull, "***Versatile capillary column temperature control using a thermoelectric array based platform***", *Analytical Chemistry*, 2011, 83, 4307-4313.

This technical paper published within the leading international analytical science journal details the completely new design and development of thermoelectric array based capillary column heaters and their potential applications. The work is undertaken by a current Ph.D.

student of mine (D. Collins) and has attracted much science media and industry attention. The design is currently under commercial development and prototype models are now being applied in several application areas, including in polymeric column production. Several invention disclosures and patent applications have also resulted from this research.
Ownership of the research reported within this paper lies primarily (>50%) with B. Paull.

8 Hassan Alwael, Damian Connolly, Paul Clarke, Roisin Thompson, Brendan Twamley, Brendan O'Connor and Brett Paull, "***Pipette-tip selective extraction of glycoproteins with lectin modified gold nano-particles on a polymer monolithic phase***", *Analyst*, 2011, 136, 2619-2628.

This research links our expertise in polymer monolithic phases with selective biochemistry for selective micro-extractions. The work, completed as part of a supervised Ph.D. project (H. Alwael), demonstrates the utility of immobilised gold nano-particles to bind bio-ligands, which maintain their bioselectivity. The pipette tip format was designed for future automation, and has generated significant industrial interest with regard to the generation of new lectin affinity chromatography phases.
Ownership of the research reported within this paper lies primarily (>40%) with B. Paull.

9 Damian Connolly, Brendan Twamley and Brett Paull, "***High-capacity gold nano-particle functionalised polymer monoliths***", *Chemical Communications,* 2010,46,2109-2111.

This is the first publication detailing the complete high density surface modification of polymer monolithic phases with gold nano-particles. The research, carried out by my post-doctoral researcher (D. Connolly), used new immobilisation strategies to produce a dense coverage of gold upon the porous monolithic scaffold. This work developed into several new projects on bioligand immobilisation, withn our own group and elsewhere [115, 127, 130].
Ownership of the research reported within this paper lies primarily (>50%) with B. Paull.

10 Xiaoyun He, L. Zhou, Ekaterina P. Nesterenko, Pavel N. Nesterenko, Brett Paull, Jesse O. Omamogho, Jeremy D. Glennonand John H.T. Luong,"***Porous Graphitized***

Carbon Monolith as Electrode Material for Probing Direct Bioelectrochemistry and Selective Detection of Hydrogen Peroxide", *Analytical Chemistry*, 2012, 84,2351-2357.

This recently published paper in the leading analytical science journal shows a novel application of new monolithic conducting carbon rods, developed by past and current supervised Ph.D. students (A. Eltmimi [104] and X. He), for selective bioelectrochemistry assays.The work has immediately lead to new collaborative research in conducting porous rods and composite carbon materials.

Ownership of the research reported within this paper lies primarily (>30%) with B. Paull.

Dedication

This collection of work is dedicated to my wife Annette, and our two beautiful girls, Eliza and Fleur.

Success in life is only judged on how much one loves, and by how much one is loved.

Contents

Peer Reviewed Journal Articles

No.	Article Type	Authors	Title	Pages	Volume	Year	Journal
1	Communication	P. Jones and B. Paull	Study of aluminium speciation in potable waters from the south west of England using ion chromatography	402-404	29	1992	*Analytical Proceedings*
2	Paper	B. Paull, M. Foulkes and P. Jones	High-performance chelation ion chromatographic determination of trace metals in coastal seawater using dye-impregnated resins	937-941	119	1994	*The Analyst*
3	Paper	P. Jones, M. Foulkes and B. Paull	Determination of barium and strontium in calcium-containing matrices using high-performance chelation ion chromatography	173-179	673	1994	*Journal of Chromatography A*
4	Communication	B. Paull, M. Foulkes and P. Jones	Determination of alkaline earth metals in offshore oil-well brines using high-performance chelation ion chromatography	209-211	31	1994	*Analytical Proceedings*
5	Paper	B. Paull and P. Jones	A comparative study of the metal selective properties of chelating dye impregnated resins for the ion chromatographic separation of trace metals	528-538	42	1996	*Chromatographia*
6	Paper	F. Hao, B. Paull and P.R. Haddad	The retention behaviour of thorium(IV) and uranyl on a reversed-phase column using glycolate and mandelate eluents	151-161	739	1996	*Journal of Chromatography A*
7	Communication	B. Paull, P. Fagan and P.R. Haddad	Determination of calcium and magnesium in natural waters using	193-196	33	1996	*AnalyticalCommunications*

			a porous graphitic carbon column with a selective metallochromic ligand as a component of the mobile phase				
8	Paper	F. Hao, B. Paull and P.R. Haddad	The determination of trace levels of thorium and uranyl by reversed-phase chromatography with on-line preconcentration and ligand exchange	103-113	749	1996	*Journal of Chromatography A*
9	Paper	F. Hao, B. Paull and P.R. Haddad	Determination of thorium and uranyl in nitrophosphate solution by on-line matrix elimination reversed-phase chromatography	690-696	42	1996	*Chromatographia*
10	Paper	M. Macka, B. Paull, P. Andersson and P.R. Haddad	The determination of barium and strontium by capillary electrophoresis using an electrolyte containing Sulfonazo III	303-310	767	1997	*Journal of Chromatography A*
11	Paper	P. Fagan, B. Paull, P.R. Haddad, R. Dunne and H. Kamar	Ion chromatographic analysis of cyanate in gold processing samples containing large concentrations of metallo-cyanide complexes	175-183	770	1997	*Journal of Chromatography A*
12	Paper	Q.Huang, B.Paull and P.R.Haddad	Optimisation of selectivity in the separation of metallo-cyanide complexes by ion-interaction liquid chromatography	3-11	770	1997	*Journal of Chromatography A*
13	Paper	K. Ohta, K. Tanaka, B. Paull and P.R. Haddad	Retention behaviour of alkali, alkaline earth and transition metal cations by ion chromatography with an unmodified silica gel column	219-227	770	1997	*Journal of Chromatography A*
14	Paper	B. Paull, M. Macka and P.R. Haddad	Determination of calcium and magnesium in water samples by high performance liquid	329-337	789	1997	*Journal of Chromatography A*

			chromatography using a graphitic stationary phase and a mobile phase containing *o*-cresolphthaleincomplexone				
15	Paper	K. Ohta, H. Morikawa, K. Tanaka, Y. Uryu, B. Paull and P.R. Haddad	Ion chromatographic behaviour of alkali and alkaline earth metal cations on silica gel columns with cation exchange characteristics	255-261	359	1998	*AnalyticaChimicaActa*
16	Paper	M. Macka, B. Paull, D.P. Bogan and P.R. Haddad	Role of ligand purity in separations of alkaline earth metals as arsenazo I complexes by capillary zone electrophoresis	177-185	793	1998	*Journal of Chromatography A*
17	Paper	B. Paull, M. Clow and P.R. Haddad	Separation and visible detection of alkaline earth metals on a polymeric reversed-phase column with mobile phase containing a selective colour-forming chelating ligand	95-103	804	1998	*Journal of Chromatography A*
18	Communication	B. Paull and P.R. Haddad	The determination of trace uranyl in saline samples using high-performance chelation ion chromatography	13-16	35	1998	*Analytical Communications*
19	Communication	B. Paull, P. Nesterenko, M. Nurdin and P.R. Haddad	Separation of metal ions using a polymeric reversed-phase column and a methylthymol blue containing mobile phase	17-20	35	1998	*Analytical Communications*
20	Paper	B. Paull, P. Nesterenko and P.R. Haddad	Chelation ion chromatography of metal ions using an ODS reversed-phase column and a mobile phase containing methylthymol blue	117-126	375	1998	*AnalyticaChimicaActa*
21	Critical review	B. Paull and P.R. Haddad	Chelation ion chromatography of the of trace metals using	107-114	18	1999	*Trends in Analytical Chemistry*

			metallochromic ligands				
22	Paper	K.L. Ng, B. Paull, P.R. Haddad and K. Tanaka	Retention modelling of electrostatic and adsorption effects of aliphatic and aromatic carboxylic acids in ion-exclusion chromatography	17-27	850	1999	*Journal of Chromatography A*
23	Paper	N. Vachirapatama, B. Paull, M. Macka, C. Munker and P.R. Haddad	Determination of niobium(V) and tantalum(V) as 4-(2-pyridylazo)resorcinol-citrate ternary complexes in geological materials by ion-interaction reversed-phase high-performance liquid chromatography	257-268	850	1999	*Journal of Chromatography A*
24	Paper	B. Paull, E. Twohill and W. Bashir	Determination of trace cadmium in environmental samples using ion-interaction reversed-phase liquid chromatography with fluorescence detection	123-132	877	2000	*Journal of Chromatography A*
25	Paper	W. Bashir and B. Paull	Determination of trace alkaline earth metals in brines using chelation ion chromatography with an iminodiacetic acid bonded silica column	191-200	907	2001	*Journal of Chromatography A*
26	Paper	W. Bashir and B. Paull	Sensitive and selective ion chromatographic method for the determination of trace beryllium in water samples	301-309	910	2001	*Journal of Chromatography A*
27	Communication	D. Connolly and B. Paull	Fast separation of UV absorbing anions using ion-interaction chromatography	353-359	917	2001	*Journal of Chromatography A*
28	Paper	W. Bashir, S.G. Butler and B. Paull	Determination of lead in water samples using ion chromatography with a xylenol orange containing	1529	34	2001	*Analytical letters*

			eluent				
29	Communication	C. Johns, M. Macka, P.R. Haddad, M. King and B. Paull	Practical method for evaluation of linearity and effective pathlength of on-capillary photometric detectors for capillary electrophoresis	237-241	927	2001	*Journal of Chromatography A*
30	Paper	D. Connolly and B. Paull	Rapid determination of nitrate and nitrite in drinking water samples using ion-interaction liquid chromatography	53-62	441	2001	*Analytical ChimicaActa*
31	Paper	W. Bashir and B. Paull	Ionic strength, temperature and pH effects upon selectivity for transition and heavy metal ions when using chelation ion chromatography with an iminodiacetic acid bonded silica gel column and simple inorganic eluents	73-82	942	2002	*Journal of Chromatography A*
32	Communication	D. Connolly, L. Barron and B. Paull	Determination of urinary thiocyanate and nitrate using fast ion-interaction chromatography	175-180	767	2002	*Journal of Chromatography B*
33	Communication	D. Connolly and B. Paull	Fast ion chromatography of common inorganic anions on a short ODS column permanently coated with didodecyldimethylammonium bromide	299-303	953	2002	*Journal of Chromatography A*
34	Paper	W. Bashir, E. Tyrrell. O. Feeney and B. Paull	Retention of alkali, alkaline earth and transition metals on an itaconic acid cation exchange column: Eluent pH, ionic strength and temperature effects upon selectivity	113-122	964	2002	*Journal of Chromatography A*

35	Paper	E. Twohill and B. Paull	Zwitterionic ion chromatography using a dynamically coated column and eluent recycling	103-113	973	2002	*Journal of Chromatography A*
36	Communication	M. King, B. Paull, P.R. Haddad and M. Macka	Performance of a simple UV LED light source in the capillary electrophoresis of inorganic anions using a chromate background electrolyte	1564-1567	127	2002	*The Analyst*
37	Communication	E. Sugrue,P. Nesterenkoand B. Paull	Iminodiacetic acid functionalised monolithic silica chelating ion exchanger for rapid determination of alkaline earth metal ions in high ionic strength samples	417-420	128	2003	*The Analyst*
38	Paper	B. Paull and W. Bashir	Non-trivial temperature effects on the cation exchange chromatography and chelation ion chromatography of metal ions	335-344	128	2003	*The Analyst*
39	Critical review	B. Paull and M. King	Quantitative capillary electrophoresis of inorganic anions – a review	1892-1934	24	2003	*Electrophoresis*
40	Paper	M. King, M. Macka and B. Paull	Rapid capillary electrophoretic method for trace chromium speciation using a zwitterionic isoelectric polymer coated capillary and photodiode array detection	2771-2787	37	2004	*Analytical Letters*
41	Paper	E. Tyrrell, C. Gibson, B. MacGraith, D. Gray, N. Kent and B. Paull	Development of a micro-fluidic manifold for copper monitoring using chemiluminescense detection	384-390	4	2004	*Lab-on-a-chip*
42	Paper	L. Barron and B. Paull	Direct detection of trace haloacetic acids in drinking water using micro-bore ion chromatography;	205-212	1047	2004	*Journal of Chromatography A*

			Improved detector sensitivity using a hydroxide gradient and a monolithic ion-exchange type suppressor				
43	Paper	B. Paull, D. Victory and D. Connolly	Rapid, low pressure and simultaneous ion chromatography of common inorganic anions and cations on short permanently coated monolithic columns	912-920	27	2004	*Journal of Separation Science*
44	Paper	E. Sugrue, P. Nesterenko and B. Paull	Ion exchange properties of monolithic and particle type iminodiacetic acid modified silica	921-930	27	2004	*Journal of Separation Science*
45	Communication	D. Victory, P. Nesterenko and B. Paull	Low-pressure gradient micro-ion chromatography with ultra-short monolithic anion exchange column	700-701	129	2004	*The Analyst*
46	Critical review	B. Paull and L. Barron	Using ion chromatography to monitor haloacetic acids in drinking water, a review of current technologies	1-9	1046	2004	*Journal of Chromatography A*
47	Paper	L. Barron and B. Paull	Determination of haloacetic acids in drinking water using micro-bore suppressed ion chromatography with solid-phase extraction	153-161	522	2004	*AnalyticaChimicaActa*
49	Communication	C. O'Riordain, P. Nesterenko and B. Paull	Double gradient ion chromatography on a short carboxybetaine coated monolithic anion exchanger	215-217		2005	*Chemical Communications*
48	Paper	B.Paull, C. Roux, M. Dawson and P. Doble	Rapid screening of selected organic explosives by high-performance liquid chromatography using reversed-phase monolithic columns	1181-1186	49	2004	*Journal of Forensic Sciences*
50	Tutorial review	B. Paull and	Novel ion chromatographic phases	134-146	130	2005	*The Analyst*

		P. Nesterenko	for the analysis of complex matrices				
51	Critical review	B. Paull and P. Nesterenko	New possibilities in ion chromatography using porous monolithic stationary phase media	295-303	24	2005	*Trends in Analytical Chemistry*
52	Paper	C. O'Riordain, P. Nesterenko and B. Paull	Zwitterionic ion chromatography with carboxybetaine surfactant coated particle packed and monolithic type columns	71-78	1070	2005	*Journal of Chromatography A*
53	Paper	L. Barron, P. Nesterenko and B. Paull	Use of temperature programming to improve resolution of inorganic anions, haloacetic acids and oxyhalides in drinking water by suppressed ion chromatography	207	1072	2005	*Journal of Chromatography A*
54	Paper	E. Sugrue, P. Nesterenko and B. Paull	Fast ion chromatography of inorganic anions and cations on a lysine bonded porous silica monolith	167-175	1075	2005	*Journal of Chromatography A*
55	Communication	P.N. Nesterenko, M.A. Rybalko and B. Paull	Significant viscosity dependent deviations from classical van Deemter theory in liquid chromatography with porous silica monolithic columns	828-830	130	2005	*The Analyst*
56	Paper	E. Sugrue, P. Nesterenko and B. Paull	Solvent enhanced ion chromatography of alkaline earth, transition and heavy metals ions on porous monolithic silica	27-35	553	2005	*AnalyticaChimicaActa*
57	Paper	E. Nesterenko, P. Nesterenko, L. Barron and B. Paull	Flow gradient liquid chromatography using a coated anion exchange micro-column	228-235	29	2006	*Journal of Separation Science*
58	Paper	C. Ó Ríordáin, L. Barron, E.	Double gradient ion chromatography using short	111-119	1109	2006	*Journal of Chromatography A*

		Nesterenko, P.N. Nesterenko and B. Paull	monolithic columns modified with a long chained zwitterioniccarboxybetaine surfactant				
59	Paper	J. Bones, P. Nesterenko, K. Thomas and B. Paull	Dual gradient LC method for the determination of pharmaceutical residues in environmental samples using a monolithic silica reversed phase column	487-504	86	2006	*The International Journal of Environmental Analytical Chemistry*
60	Paper	L. Barron and B. Paull	Simultaneous determination of trace oxyhalides and haloacetic acids using suppressed ion chromatography-electrospray mass spectrometry	621-630	69	2006	*Talanta*
61	Paper	L. Barron, P. Nesterenko and B. Paull	Rapid online preconcentration and suppressed ion chromatography of part per trillion levels of perchlorate in rainwater samples	127-134	567	2006	*AnalyticaChimicaActa*
62	Communication	E. Gillespie, M. Macka, D. Connolly and B. Paull	Evaluation of capillary ion exchange stationary phase coating distribution and stability using radial capillary column contactless conductivity detection	886-888	131	2006	*The Analyst*
63	Paper	M. O' Toole, K-T. Lau, B. Shazmann, R. Shepherd, P.N. Nesterenko, B. Paull, and D. Diamond	Novel integrated paired emitter-detector diode (PEDD) as a miniaturized photometric detector in HPLC	938-943	131	2006	*The Analyst*
64	Paper	É. Tyrrell, P. Nesterenko and B. Paull	Flow analysis method using chelating CIM monolithic discs for monitoring dissolved labile copper	2201-2216	29	2006	*Journal of Liquid Chromatography and Related*

			in environmental water samples				*Technologies*
65	Paper	L. Barron, P. Nesterenko, D. Diamond, M. O'Toole, K- T. Lau and B. Paull	Low pressure ion chromatography with a low cost paired emitter-detector diode based detector for the determination of alkaline earth metals in water samples	32-37	577	2006	*AnalyticaChimicaActa*
66	Paper	J. Bones, K.V. Thomas and B. Paull	Improved method for the determination of zinc pyrithione in environmental water samples incorporating on-line extraction and preconcentration coupled with liquid chromatography atmospheric pressure chemical ionisation mass spectrometry	157-164	1132	2006	*Journal of Chromatography A*
67	Paper	J. Bones, P. Nesterenko and B. Paull	On-line preconcentration of pharmaceutical residues from large volume water samples using short reversed-phase monolithic cartridges coupled to LC-UV-ESI-MS	1117-1128	70	2006	*Talanta*
68	Paper	C. O'Riordain, E. Gillespie, D. Connolly, P.N. Nesterenko and B. Paull	Capillary ion chromatography of inorganic anions on octadecyl silica monolith modified with an amphoteric surfactant	185-193	1142	2007	*Journal of Chromatography A*
69	Paper	J. Bones, M. Mackaand B. Paull	Evaluation of monolithic and a sub 2µm particle packed columns for the rapid screening for illicit drugs – Application to the determination of drug contamination on Irish euro banknotes	208-217	132	2007	*The Analyst*
70	Paper	F-Q. Nie, M. Macka, L. Barron, D. Connolly, N.	Robust monolithic silica based on-chip electro-osmotic pump	417-424	132	2007	*The Analyst*

		Kent, and B. Paull					
71	Paper	J. Bones,K.V. Thomasand B. Paull	Using environmental analytical data to estimate levels of community consumption of illicit drugs and abused pharmaceuticals	701-707	9	2007	*Journal of Environmental Monitoring*
72	Communication	F-Q. Nie, M.Mackaand B. Paull	Micro-flow injection analysis system: On-chip sample preconcentration, injection and delivery using coupled monolithic electroosmotic pumps	1597-1599	7	2007	*Lab-on-a-chip*
73	Communication	E.P. Nesterenko, C. Duffy and B. Paull	Separation of nucleic acid precursors on an amphoteric surfactant modified monolith using combined eluent flow, pH and concentration gradient	2910-2916	30	2007	*Journal of Separation Science*
74	Paper	E. Gillespie, D. Connolly, M. Macka,P.N. Nesterenko and B. Paull,	Use of contactless conductivity detection for non-invasive characterisation of monolithic stationary phase coatings for application in capillary ion chromatography	1238-1245	132	2007	*The Analyst*
75	Paper	D. Connolly, V. O'Shea, P. Clarke, B. O'Connor and B. Paull	Evaluation of photografted charged sites within polymer monoliths in capillary columns using contactless conductivity detection	3060-3068	30	2007	*Journal of Separation Science*
76	Paper	E. P. Nesterenko, P.N. Nesterenko and B. Paull	Anion-exchange chromatography on short reversed-phase columns modified with amphoteric (N-dodecyl-N,N-dimethylammonio)alcanoates	60-70	1178	2008	*Journal of Chromatography A*
77	Communication	J. Bones, C. Duffy, M. Macka and B. Paull	Using coupled monolithic rods for ultra-high peak capacity LC and LC-MS under normal LC operating	180-183	133	2008	*TheAnalyst*

			pressures				
78	Paper	L. Barron, J.M. Tobin and B. Paull	Multi-residue determination of pharmaceuticals in sludge and sludge enriched soils using pressurised liquid extraction, solid phase extraction and liquid chromatography with tandem mass spectrometry	353-361	10	2008	*Journal of Environmental Monitoring*
79	Communication	E. Gillespie,D. Connolly,P.N. Nesterenko and B. Paull	Accurate non-invasive determination of pK_a of surface functionalised ion exchange monoliths using capacitively coupled contactless conductivity detection	874-876	133	2008	*The Analyst*
80	Communication	S. Abele, F-Q. Nie, F. Foret, B. Paull and M. Macka	UV-LED photo-polymerised monoliths	864-867	133	2008	*The Analyst*
81	Paper	W. Bashir, F. McGovern, P. O' Brien, M. Ryan, L. Burke and B. Paull	Chemical trends in background air quality and the ionic composition of precipitation for the period 1980-2004 from samples collected at Valentia Observatory, Co. Kerry, Ireland	730-738	10	2008	*Journal of Environmental Monitoring*
82	Paper	E. Gillespie, D. Connolly, M. Macka, P. Hauserand B. Paull	Development of a contactless conductivity detector cell for 1.6 mm O.D. (1/16th inch) HPLC tubing and micro-bore columns with on-column detection	1104-1110	133	2008	*The Analyst*
83	Communication	Z. Walsh, S.Abele, B. Lawless, D. Heger, P. Klán, M.C. Breadmore,	Photo-initiated polymerisation of monolithic stationary phases in polyimide coated capillaries using visible region LEDs	6504-6506	48	2008	*Chemical Communications*

		B. Paull and M. Macka					
84	Paper	L. Barron, M. O'Toole, D. Diamond, P.N. Nesterenkoand B. Paull	Separation of transition metals on a poly-iminodiacetic acid grafted polymeric resin column with post-column reaction detection utilising a paired emitter-detector diode system	31-36	1213	2008	*Journal of Chromatography A*
85	Paper	E.P. Nesterenko, P.N. Nesterenko and B. Paull	Simultaneous separation of inorganic anions and metal- citrate complexes on a zwitterionic stationary phase with on-column complexation	62-69	1213	2008	*Journal of Chromatography A*
86	Paper	S. Scarmagnani, Z.Walsh, C. Slater, N. Alhashimy, B. Paull, M. Macka, and D. Diamond	Polystyrene beads-based system for optical sensing using spiropyranphotoswitches	5063-5071	18	2008	*Journal of Materials Chemistry*
87	Paper	M. O' Toole, L. Barron, R. Shepherd, P.N. Nesterenko, B. Paull and D. Diamond	Paired emitter-detector diode detection with dual wavelength monitoring for enhanced sensitivity to transition metals in ion chromatography with post-column reaction	124-130	134	2009	*The Analyst*
88	Paper	L. Barron, J. Havel,M. Purcell,M. Szpakand B. Paull	Predicting sorption of pharmaceuticals and personal care products onto soil and digested sludge using artificial neural networks	663-670	134	2009	*The Analyst*
89	Paper	E. Gillespie, D. Connollyand B. Paull	Using scanning contactless conductivity to optimise photografting procedures and	1314-1321	134	2009	*The Analyst*

			capacity in the production of polymer ion-exchange monoliths				
90	Paper	B. Schazmann, F. Regan, M. Ross, D. Diamond and B. Paull	Introducing quality control in the chemistry teaching laboratory using control charts	1085-1090	86	2009	*Journal of Chemical Education*
91	Paper	F. Benito Lopez, S. Scarmagnani, Z. Walsh, B. Paull, M. Macka and D. Diamond	Spiropyran modified micro-fluidic chip channels as photonically controlled self-indicating system for metal ion accumulation and release	295-303	140	2009	*Sensors and Actuators B: Chemical*
92	Communication	D. Connolly, L. Barron and B. Paull	The use of contactless conductivity for the on-column characterisation and visualisation of packing homogeneity and band broadening in capillary LC	915-920	70	2009	*Chromatographia*
93	Critical review	E.P. Nesterenko, P.N. Nesterenko and B. Paull	Zwitterionic ion-exchangers in ion chromatography: A review of recent developments	3-21	652	2009	*AnalyticaChimicaActa*
94	Paper	E. Gillespie, D. Connolly, P.N. Nesterenko and B. Paull	On-column titration and investigation of metal complex formation for aminopolycarboxylate functionalised monoliths using scanning contactless conductivity detection	2659-2667	32	2009	*Journal of Separation Science*
95	Communication	D. Connolly and B. Paull	High-performance separation of small inorganic anions on a methacrylate-based polymer monolith grafted with [2(methacryloyloxy)ethyl] trimethylammonium chloride	2653-2658	32	2009	*Journal of Separation Science*,
96	Paper	S. Scarmagnani,	Photoswitchable stationary phase	649-652	7	2009	*e-Journal of Surface*

		Z. Walsh, F. Benito Lopez, C. Slater, M. Macka, B. Paull and D. Diamond	based on packed spiropyranfunctionalised silica microbeads				*science and Nanotechnology*
97	Communication	L. Krcmova, A. Stjernlof, S. Mehlen, P. Hauser, S. Abele, B. Paull and M. Macka	Deep-UV LEDs in photometric detection: A 255 nm LED on-capillary detector in capillary electrophoresis	2394-2396	134	2009	*The Analyst*
98	Paper	S. Scarmagnani, C. Slater, F. Benito Lopez, D. Diamond, Z. Walsh, B. Paull and M. Macka	Photoreversible ion-binding using spiropyran modified silica microbeads	38-52	5	2010	*International Journal of Nanomanufacturing*
99	Paper	Z. Walsh, P.A. Levkin, B. Paull, F. Svec and M. Macka	Visible light initiated polymerisation of styrenic monolithic stationary phases using 470 nm light emitting diode arrays	61-66	33	2010	*Journal of Separation Science*
100	Paper	M. Ryvolová, J. Preisler, F. Foret, P. Hauser, P. Krásenský, B. Paull and M. Macka	Combined contactless conductometric, photometric and fluorimetric single point detector for capillary separation methods	129-135	82	2010	*Analytical Chemistry*
101	Paper	S. Currivan, D. Connolly, E. Gillespie and B. Paull	Fabrication and characterisation of capillary polymeric monoliths incorporating continuous stationary phase gradients	484-492	33	2010	*Journal of Separation Science*
102	Communication	D. Connolly, B. Twamley and	High- capacity gold nano-particle functionalised polymer monoliths	2109-2111	46	2010	*Chemical Communications*

		B. Paull					
103	Paper	E. Nesterenko, P.N. Nesterenko, D. Connolly, F. Lacroix and B. Paull	Micro-bore titanium housed polymer monoliths for reversed-phase liquid chromatography of small molecules	2138-2146	1217	2010	*Journal of Chromatography A*
104	Paper	A.H. Eltmimi, L. Barron, A. Raffery, J.P. Hanrahan, O. Fedyanina, E. Nesterenko, P.N. Nesterenko and B. Paull	Preparation, characterisation and modification of carbon based monolithic rods for chromatographic applications	1231-1243	33	2010	*Journal of Separation Science*
105	Paper	L. Barron, E. Nesterenko, K. Hart, E. Power, B. Quinn,B. Kelleher and B. Paull	Holistic visualisation of the multimodal transport and fate of twelve pharmaceuticals in biosolid enriched topsoils	287-296	397	2010	*Analytical and Bioanalytical Chemistry*
106	Critical review	M. Vasquez and B. Paull	Review on recent and advanced applications of monoliths and related porous polymer gels in micro-fluidic devices	100-113	668	2010	*AnalyticaChimicaActa*
107	Paper	H. Alwael, D. Connolly, L. Barron and B. Paull	Development of a rapid, accurate and sensitive method for determination of cysteine/cystine ration in chemically defined media	3863-3870	1217	2010	*Journal of Chromatography A*
108	Critical review	D. Connolly, P. Floris, P.N. Nesterenko and B. Paull	Non-invasive characterisation of stationary phases in capillary flow systems using scanning capacitively coupled contactless conductivity detection (sC4D)	870-884	29	2010	*Trends in Analytical Chemistry*

109	Paper	Z. Walsh,S. Scarmagnani,F. Benito-López,S. Abele,F-Q. Nie,C. Slater,R. Byrne,D. Diamond,B. Paull and M. Macka	Photochromic spiropyranmonolithic polymers: molecular photo-controllable electroosmotic pumps for micro-fluidic devices	569-576	148	2010	*Sensors and Actuators B: Chemical*
110	Communication	Z. Walsh, M. Vázquez, F. Benito-López,B. Paull, M.Macka, F. Svec and D. Diamond	The use of scanning contactless conductivity detection for the characterisation of stationary phases in micro-fluidic chips	1777-1780	10	2010	*Lab on a Chip*
111	Paper	S. Scarmagnani, Z. Walsh, F. Benito-Lopez, M. Macka, B. Paull and D. Diamond	Incorporation of acrylate based spiropyran monoliths in micro-fluidic devices for photo-controlled electroosmotic flow	100-105	76	2010	*Advances in Science and Technology*
112	Paper	H. Alwael, D. Connolly and B. Paull	Liquid chromatographic profiling of monosaccharide concentrations in complex cell-culture media and fermentation broths	62-69	3	2010	*Analytical Methods*
113	Paper	E. Nesterenko, O. Yavorska, M. Macka, A. Yavorskyy and B. Paull	Monolithic porous layer open tubular (monoPLOT) columns for low pressure liquid chromatography of proteins	537-543	3	2011	*Analytical Methods*
114	Paper	T.Piasecki, M. Macka, B. Paull, and D. Brabazon	Numerical model for light propagation and light intensity distribution inside coated fused silica capillaries	924-931	49	2011	*Optics and Lasers in Engineering*
115	Paper	H. Alwael, D.	Pipette-tip selective extraction of	2619-	136	2011	*Analyst*

		Connolly, P. Clarke, R. Thompson, B. Twamley, B. O'Connor and B. Paull	glycoproteins with lectin modified gold nano-particles on a polymer monolithic phase	2628			
116	Paper	Z. Walsh, P.A. Levkin, S. Abele, S. Scarmagnani, D. Heger, P.Klán, D. Diamond, B. Paull, F. Svecand M. Macka	Polymerisation and surface modification of methacrylate monoliths in polyimide channels and polyimide coated capillaries using 660 nm light emitting diodes	2954-2962	1218	2011	*Journal of Chromatography A*
117	Paper	A. Spence, A. J. Simpson, D. J. McNally, B.W. Moran, M. V. McCaul, K. Hart, B. Paull and B.P. Kelleher	The degradation characteristics of microbial biomass in soil	2571-2581	75	2011	*Geochimica et CosmochimicaActa*
118	Technical communication	D. Collins, E. Nesterenko, D. Connolly, M. Vasquez, M. Macka, D. Brabazon and B. Paull	Versatile capillary column temperature control using a thermoelectric array based platform	4307-4313	83	2011	*Analytical Chemistry*
119	Critical Review	M. Vazquez, D. Brabazon, F.J. Shang, J.O. Omamogho, J.D. Glennon and B. Paull	Centrifugally-driven sample extraction, preconcentration and purification in microfluidic compact discs	1575-1586	30	2011	*TRAC-Trends in Analytical Chemistry*

120	Paper	X. He, L. Zhou, E.P. Nesterenko, P.N. Nesterenko, B. Paull, J.O. Omamogho, J.D. Glennonand J. H.T. Luong	Porous graphitized carbon monolith as an electrode material for probing direct bioelectrochemistry and selective detection of hydrogen peroxide	2351-2357	84	2012	*Analytical Chemistry*
121	Technical communication	D. Collins, E. Nesterenko, D. Brabazon and B. Paull	Controlled UV photo-initiated fabrication of monolithic porous layer open tubular (monoPLOT) capillary columns for chromatographic applications	3465-3472	84	2012	*Analytical Chemistry*
122	Paper	S. Currivan, D. Connolly and B. Paull	Production of novel polymer monolithic columns, with stationary phase gradients, using cyclic olefin co-polymer (COC) optical filters	2559-2566	137	2012	*Analyst*
123	Critical Review	Z. Walsh, B. Paull and M.Macka	Inorganic monoliths in separation science: A review	28-47	750	2012	*AnalyticaChimicaActa*
124	Critical Review	D. Connolly, S. Currivan and B. Paull	Polymeric monolithic materials modified with nano-particles for separation and detection of biomolecules: A review.	2904-2917	12	2012	*Proteomics*
125	Paper	A. Moyna, D. Connolly, E. Nesterenko, P.N. Nesterenko and B. Paull	Separation of selected transition metals by capillary chelation ion chromatography using iminodiacetic acid modified capillary polymer monoliths	155-163	1249	2012	*Journal of Chromatography A*
126	Paper	H. Alwael, D. Connolly and B. Paull	Rapid and sensitive chromatographic determination of free sialic acid in complex bio-pharma fermentation media	2668-2673	4	2012	*Analytical Methods*

			samples				
127	Paper	P. Floris, H. Alwael, B. Twamley, P.N. Nesterenko, B. Paull and D. Connolly	Agglomerated polymer monoliths with bimetallic nano-particles as flow-though micro-reactors	149-156	179	2012	*MicrochimicaActa*
128	Paper	A. Moyna, D. Connolly, E. Nesterenko, P.N. Nesterenko and B. Paull	Iminodiacetic acid functionalised monoliths: Application to the separation of metal cations by capillary high performance chelation ion chromatography	2207-2217	405	2013	*Analytical and Bioanalytical Chemistry*
129	Paper	N. Mcgillicuddy, E.P.Nesterenko, P.N Nesterenko, P. Jones and B. Paull	Chelation ion chromatography of alkaline earth and transition metals using a monolithic silica column with bonded N-hydroxyethyliminodiacetic acid functional groups	102-111	1276	2013	*Journal of Chromatography A*
130	Paper	D.A. Collins, E.P. Nesterenko, D. Brabazon and B. Paull	In-process phase growth measurement technique in the fabrication of monolithic porous layer open tubular (monoPLOT) columns using capacitively coupled contactless conductivity	2540-2545	138	2013	*Analyst*
131	Paper	E.P. Nesterenko, P.N. Nesterenko, B. Paull, M.M. Oyola and J. Corredor	Fast direct determination of strontium in seawater using high-performance chelation ion chromatography	8-15	111	2013	*Microchemical Journal*
132	Paper	S. Currivan, D. Connolly and B. Paull	Production of polymer monolithic capillary columns with integrated gold nano-particle modified	32-39	111	2013	*Microchemical Journal*

			segments for on-capillary extraction				
133	Paper	A.A. Kazarian, M.R. Taylor, P.R. Haddad, P.N. Nesterenko and B. Paull	Ion-exchange and hydrophobic interactions affecting selectivity for neutral and charged solutes on three structurally similar agglomerated ion-exchange and mixed-mode stationary phases.	*In-press*		2013	*AnalyticaChimicaActa*
134	Paper	D. Collins, E. Nesterenko, D. Brabazon, and B. Paull	Fabrication of bonded monolithic porous layer open tubular (monoPLOT) columns in wide bore capillary by laminar flow thermal initiation	581-589	76	2013	*Chromatographia*
135	Paper	D.P. Mitev, A.T. Townsend, B. Paull and P.N. Nesterenko	Direct sector field ICP-MS determination of metal impurities in detonation nanodiamond	326-334	60	2013	*Carbon*
136	Paper	N. McGillicuddy, E.P. Nesterenko, P. Jones, A.T. Townsend, D. Mitev, P.N. Nesterenko, B. Paull	Direct determination of transition and heavy metals in mussel tissue digests using high-performance chelation ion chromatography with monolithic silica based chelating ion exchangers	2666-2673	5	2013	*Analytical Methods*
137	Critical Review	E.P. Nesterenko, P.N. Nesterenko, D. Connolly, X. He, P. Floris, E. Duffy and B. Paull	Nano-particle modified stationary phases for high-performance liquid chromatography	4229-4254	138	2013	*Analyst*

Peer Reviewed Conference Proceedings (not submitted herein)

	Article Type	Authors	Title	Pages	Volume	Year	Journal	Editors	Publishers/ISBN
138	Reviewed Proceedings	C. Gibson, P. Byrne, D.Gray, B.MacCraith, B. Paull and E.Tyrrell	Design of a micro-fluidic sensor for high sensitivity copper(II) sensing applications	615	4876	2003	*Proc. Opto-Ireland 2002: Optics and Photonics Technologies and Applications*	T.J. Glynn	SPIE – International Society for Optical Engineering
139	Reviewed Proceedings	W. Bashir, M. Ryan, L. Burke, F. McGovern and B. Paull	An analysis of the ionic composition of Irish precipitation and background air quality since 1980 based on samples collected at Valentia Observatory, Co. Kerry, Ireland	545-555		2006	*Air Pollution XIV*	J.W.S. Longhurst, C.A. Brebbia	WIT Press
140	Reviewed Proceedings	F-Q.Nie, M. Macka and B. Paull	Integrating independent silica monolith electroosmotic pumps for reagent delivery and sample preconcentration in a μ-TAS device	829-831	1	2007	*Proc. μTAS 2007 11th International Conference on Miniaturized Systems in Chemistry and Life Sciences*	J.L. Viovy, P. Tabeling, S. Decroix, L. Malaquin	The Chemical and Biological Microsystems Society ISBN: 978-0-9798064-0-7
141	Reviewed Proceedings	S. Scarmagnani, Z. Walsh, N. Alhashimy, A.Radu, B. Paull, M. Macka, and D. Diamond	Beads-based system for optical sensing using spiropyranphotoswitches	4096-4097		2007	*Proc. 29th Annual International Conference of the IEEE*		Engineering in Medicine and Biology Society
142	Reviewed Proceedings	A.B.Azouz, S. Karazi, D. Brabazon, M.	Effect of laser processing parameters and glass type on	496-499	2	2010	*Proc. Nanotech 2010 Conference*		ISBN 978-1-4398-3402-2

		Vazquez, M. Macka and B. Paull	topology of micro-channels						
143	Reviewed Proceedings	A.B. Azouz, T. Piasecki, D. Brabazon, M. Vazquez, M. Macka and B. Paull	Laser Induced plasma and glass type effect on the process of micro-channel fabrication using CO_2 laser	P5.318	34A	2010	*Proc. 37th EPS Conference on Plasma Physics*		ISBN 2-914771-62-2
144	Reviewed Proceedings	A. Ben Azouz, R. O'Connor, M. Vázquez, D. Brabazon and B. Paull	Cyclic olefin copolymer strip processing for freeform fabrication of multi-layered microfluidic sensing systems	128-139		2010	*Proc. 23rd Annual International Solid Freeform Fabrication Symposium*		Lab. Freeform Fabrication, University of Texas, Austin
145	Reviewed Proceedings	A.B. Azouz, M. Vazquez, B. Paull and D. Brabazon	Laser processing of quartz for micro-fluidic device fabrication	436-441	445	2012	*Proc. Materials and manufacturing Technologies XIV*	F. Yigit, M. S. J. Hashmi	Advanced Materials Research, Scientific.net

Non-Peer Reviewed Journal Articles (not submitted herein)

	Article Type	**Authors**	**Title**	**Pages**	**Volume**	**Year**	**Journal**	**Publishers/ISBN**
146	Short discussion paper	Q. Huang, B. Paull and P.R. Haddad	Comparison of cyanide speciation by liquid chromatography and standard distillation methods	310	July	1996	*Chemistry in Australia*	Royal Australian Chemistry Institute
147	Short review	B. Paull and P. Nesterenko	New phases for rapid ion analysis	47	10(1)	2005	*European Pharmaceutical Review*	Russell Publishing Ltd
148	Short discussion paper	J. Bones and B. Paull	Expanding analytical chemistry to community wide measurements -	7-9	23(1)	2007	*Irish Chemical News*	Institute of Chemistry of Ireland

			estimating the consumption of illicit drugs within Irish society					
149	Short discussion paper	D. Collins, D. Connolly, M. Macka and B. Paull	Application of dynamic temperature gradients and profiles for capillary LC through the application of a new thermoelectric array based column heater	30-31	September	2010	*Chromatography Today*	The Chromatographic Society

Book Chapters (not submitted herein)

	Article Type	Authors	Title	Pages	Year	Book	Editors	Publishers/ISBN
150	Book Chapter	B. Paull, P. Nesterenko and L. Barron	The determination of phosphates in environmental samples by ion chromatography	263-287	2005	*Chromatographic Analysis of the Environment: Third Edition*	L. Nollet	CRC Press/ 9780824726294
151	Book Chapter	B. Paull	Chromatography	Section 212	2005	*Handbook of Measuring System Design*	P. Sydenham, R. Thorn	Wiley
152	Book Chapter	B. Paull	Ion Exchange: (d) Ion chromatography applications		2005	*Encyclopaedia of Analytical Science, Second Edition*	P. Worsfold, A. Townshend, C. Poole	Elsevier Ltd
153	Book Chapter	B. Paull and D. Connolly	Monolithic ion exchange phases for the separation of small inorganic ions	265-318	2010	*Monolithic Chromatography and Its Modern Applications*	P. Wang	ILM Publications/ 9781906799038
154	Book Chapter	T. Piasecki, A. Ben Azouz, B. Paull, M. Macka and D. Brabazon	Numerical modelling of light propagation for development of capillary electrophoretic and photochemical detection systems	41-62	2012	*Electrophoresis*	K. Ghowsi	InTech open Science/ 9789535108467

155	Book Chapter	B. Paull and P. Nesterenko	Ion Chromatography	157-190	2013	*Handbooks in Separation Science: Liquid Chromatography*	S. Fanali, P.R. Haddad, D. Lloyd, C.F. Poole, P.J. Schoenmakers	Elsevier Ltd

Books (not submitted herein)

	Book Type	**Authors**	**Title**	**Pages**	**Year**	**Series**	**Series Editor**	**Publishers/ISBN**
156	Monograph	P. N. Nesterenko, P. Jones and B. Paull	High-performance chelation ion chromatography	1-303	2010	*Chromatography Monographs*	R.M. Smith	Royal Society of Chemistry Publishing/ 9781849730419

PDF copies of the publications numbered 1 to 156 have been removed due to Copyright restrictions.

Appendix 1

Post-graduate research students who have contributed to this collection of works.

Graduate	Award Year	Research Degree	Thesis Title	Supervisors (*Primary)
Dr. F. Hao	1996	Ph.D. (Tasmania)	*The determination of thorium and uranium by reversed-phase HPLC*	*P.R. Haddad and B. Paull
Dr. K.L. Ng	2000	Ph.D. (Tasmania)	*Mechanistic studies on carboxylic acid retention in ion exclusion chromatography*	*P.R. Haddad and B. Paull
Dr. N. Vachirapatama	2000	Ph.D. (Tasmania)	*Separation of niobium and tantalum by reversed-phase HPLC*	*P.R. Haddad and B. Paull
Dr. W. Bashir	2002	Ph.D. (Dublin City)	*Development of complexation ion chromatography for the determination of metal ions*	*B. Paull
Ms. E. Twohill	2002	M.Sc. (Dublin City)	*Investigation of electrostatic ion chromatography for the separation of inorganic ions*	*B. Paull
Dr. M. King	2003	Ph.D. (Dublin City)	*Further development of capillary electrophoresis for the quantitative determination of small inorganic anions*	*B. Paull
Dr. D. Connolly	2005	Ph.D. (Dublin City)	*Development of fast ion chromatography*	*B. Paull
Ms. D. Victory	2005	M.Sc. (Dublin City)	*Development of low pressure ion chromatography for the separation of anions*	*B. Paull
Dr. E. Tyrrell	2005	Ph.D. (Dublin City)	*Development of a micro-fluidic based analytical system for copper monitoring in environmental water samples*	*B. Paull
Dr. L. Barron	2005	Ph.D. (Dublin City)	*Ion chromatographic analysis of disinfection by-products*	*B. Paull
Dr. C. O'Riordain	2006	Ph.D. (Dublin City)	*Zwitterionic ion chromatography of common inorganic anions using stationary phases modified with carboxybetaine type surfactants*	*B. Paull
Dr. E. Sugrue	2006	Ph.D. (Dublin City)	*Development and characterisation of silica monolithic stationary phases for ion chromatography*	*B. Paull
Dr. J.J. Bones	2007	Ph.D. (Dublin City)	*Extraction and analysis of pharmaceutical residues in environmental samples using SPE and LC-MS/MS*	*B. Paull

Dr. E.P. Nesterenko	2008	Ph.D. (Dublin City)	*The investigation of ion-exchange properties of novel zwitterionic and amphoteric stationary phases and their application to the separation of inorganic and organic ions*	*****B. Paull
Ms. M. Purcell	2009	M.Sc. (Dublin City)	*High performance liquid chromatography-tandem mass spectrometry of pharmaceuticals and personal care products in environmental and biological matrices*	*****B. Paull
Dr. E. Gillespie	2009	Ph.D. (Dublin City)	*The formation, modification and characterisation of monolithic ion exchangers for separation science*	*B. Paull and D. Connolly
Dr. A. Eltmimi	2009	Ph.D. (Dublin City)	*Preparation, characterisation and modification of porous carbon monolithic materials for chromatographic and electrochemical applications*	*B. Paull and P. Nesterenko
Dr. Z. Walsh	2010	Ph.D. (Dublin City)	*Exotic monoliths*	*M. Macka and B. Paull
Dr. T. Piasecki	2011	Ph.D. (Dublin City)	*Electrohydrodynamic focusing and light propagation in 2-dimensional micro-fluidic devices for preconcentration of low abundance bioanalytes*	*D. Brabazon, M. Macka and B. Paull
Dr. H. Alwael	2012	Ph.D. (Dublin City)	*Development of rapid chromatographic technologies for complex biofermentation sample analyses*	*B. Paull and D. Connolly
Dr. A. Moyna	2012	Ph.D. (Dublin City)	*The formation and modification of polymer monoliths for the separation of small ions*	*B. Paull and D. Connolly
Dr. S. Currivan	2012	Ph.D. (Dublin City)	*Development of stationary phase gradients and multi-functional stationary phases in capillary format*	*B. Paull and D. Connolly
Dr. D. Collins	2013	Ph.D. (Dublin City)	*Novel tools for polymer monolithic capillary column production and chromatographic appliction*	*B. Paull, E. Nesterenko and D. Brabazon
Mr. A. Alwy	2013	M.Sc. (Dublin City)	*Fabrication and characterisation of nano-agglomerated monolithic stationary phases for separation science*	*D. Connolly and B. Paull