

## **1990-1996: The Early Years**

Let me just preface this by saying that in late 1990, I had just been issued with an “electronic mail address”; had to attend a course to learn how to use it and there were less than 5 million webpages worldwide and the internet browser was “NCSA Mosaic”. The telex and fax machine were our regular form of communication along with letters around the world to researchers. To meet researchers, you travelled or arranged a call with them. Communications were very different from today.

### 1990-1991

My career in thermal conversion started on 3<sup>rd</sup> September 1990 when I started employment at Aston University, Department of Chemical Engineering and Applied, Chemistry, Energy Research Group (as it was called then) headed by Dr. Tony Bridgwater. I was a research assistant, and the primary aim was to build an ablative fast pyrolysis reactor to make pyrolysis liquids. My PhD was a secondary gain from the contract – completion of the EC Contract the primary focus.

I was employed to work on the multi-European partner JOULE contract, "JOUB-CT90-0032-C (GDF): Advanced Flash pyrolysis of biomass for liquids", which had the Institute of Wood Chemistry [IWC] and University of Twente as partners.

The laboratory was not geared up to pyrolysis: there was an abandoned molten salts pyrolysis rig and time was spent making the laboratory "useable". The other occupants were Dr. Geraint Evans and Dr. Jimmy Milligan working with a 2 kg/h quartz downdraft reactor and that was it. So, along with designing an ablative pyrolysis reactor, there was the task of building up a pyrolysis laboratory – from scratch. Working at Aston, you have to be highly motivated to make it all work on your own and drive the agenda yourself.

In April 1991 while attending the EU Biomass and Bio-energy Conference in Vouliagmeni, Athens, Tony introduced me to Dr. Desmond Radlein of the famous University of Waterloo Research Group, led by Prof. Don Scott. Aston needed to test some sorghum bagasse on behalf of the European Commission, so it was agreed that I could travel to the University of Waterloo to run the trials while my own rig was being built at Aston. 2 months later I'm in the University of Waterloo laboratory, with Piotr Majerksi, Jan Piskorz, Desmond Radlein and Don Scott. So, in July 1991 as the University of Waterloo were my first trials and training in fast pyrolysis for 4+ weeks to pyrolyse the sweet sorghum bagasse and carry out analyses and mass balances. I will always remember that.

Upon return, I proceeded with my own work and there only myself doing practical pyrolysis work. From that point on, the plan was to build an ablative pyrolysis rig, then with the help of University of Waterloo, build a 150 g/h fluid bed rig. Over time, this expanded to a 1.5 kg/h rig, then a basis for a 5 kg/h rig.

## 1992-1994

As 1992 proceeded, my own reactor was not ready, but the small fluid bed was on the go and so as noted, we expanded capabilities: GC analysis of the cleaned syngas, KF- water titration, HPLC analysis in close co-operation with the University of Waterloo and expanding the laboratory basic services. The ERG expanded and more students and researcher came on board as more EC-funded work was awarded. ERG also took on determination of the thermal conductivity and specific heat capacity of pyrolysis liquids in 1992/3, one of the first laboratories to determine this data.

In late 1992, my own rig was finally ready, taking a year longer than expected and trials could begin. When you're building your own reactor, you need mechanical, electrical, control and instrumentation skills and knowledge.

At this time, I was also attending IEA Pyrolysis Task 34 meetings in various locations, EC-Canada Collaboration meetings and many contractors meetings. I was asked to contribute and work on a range of contracts all relating to pyrolysis [list at the end].

The fluid bed reactors came as the basic hardware – Aston had to turn the into operational pyrolysis rigs, which took time. By late 1994 the lab had multiple reactors or others under build:

- 150 g/h fluid bed reactor with condensers and electrostatic precipitator
- 300 g/h fluid bed reactor with liquids quench and electrostatic precipitator [late 1995]
- 1.5 kg/h fluid bed reactor with liquids quench and electrostatic precipitator
- 5 kg/h fluid bed reactor with liquids quench and electrostatic precipitator
- 5 kg/h ablative pyrolysis reactor with 2x scrubbers and fabric filters.

These reactor systems are shown below and a list of publications that I was an author on are given. Improvements were continually made to allow longer runs, improved reliability, make bulk liquid samples, do testing and train other researchers.

As the now named Bio-Energy Research Group grew, then more of my time was spent supervising and training students. In 1994 I was awarded my PhD for the ablative pyrolysis work and the EC-contract was finished some months earlier.

## 1995-1996

As I now had 5+ years of practical experience in pyrolysis, working on multiple rigs, design and build, my second ablative reactor design concept was picked up and built by Nick Robinson and was subsequently patented by the University in 2010.

1995 saw the arrival and build of the 5 kg/h fluid bed reactor, which was again supplied by University of Waterloo and then assembled at Aston. Mr. Robert Hague and Mr. Colin Dick heavily involved in that work for their own research purposes.

I participated in many contracts and became involved in liquids combustion in engines, upgrading, feedstock pretreatment, hot gas filtration and many related activities. I had decided that academia was not the career path for me, as I wanted to apply my skills to larger scale processes, but as a consulting engineer and so in September 1996 – Conversion And resource Evaluation was formed.

My 6 years at Aston led to me attending many conferences and meetings in Europe and North America: seeing other researchers work, equipment, facilities and led to many interesting and useful discussions and connections that still exist 35 years later. There are too many topics to cover and review, but consult the referred papers for more information, but the time and experience provided my grounding for my career in thermal conversion.

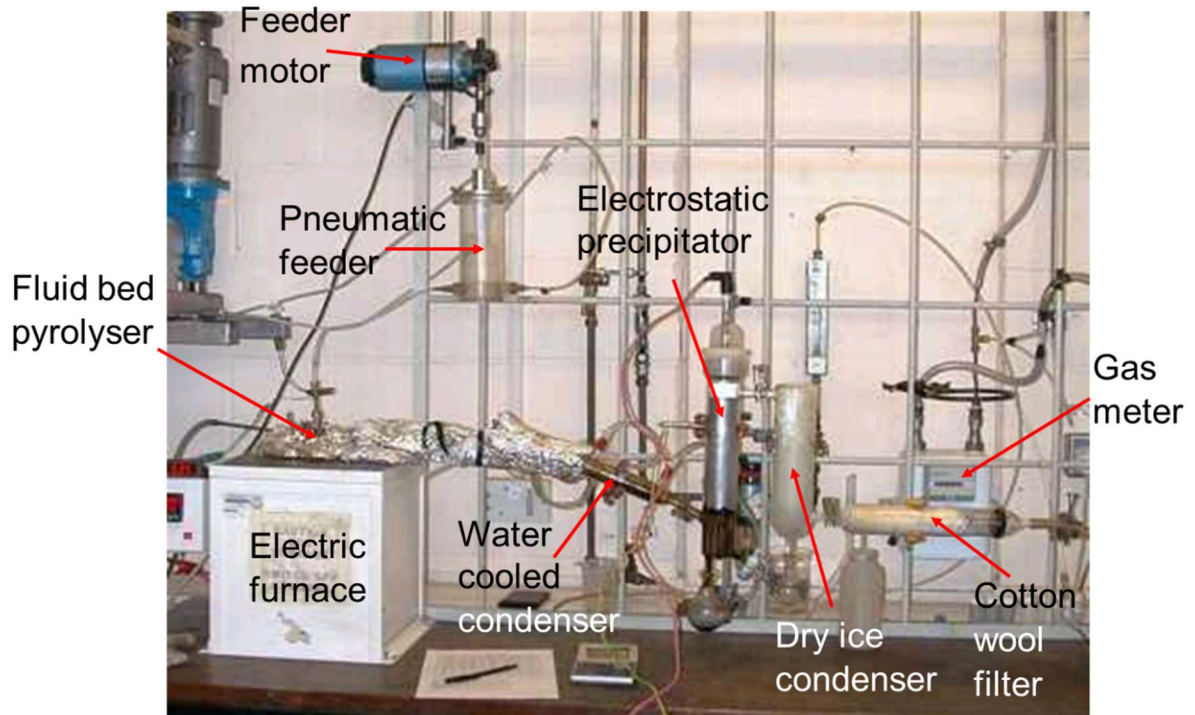
### **General R&D Advice**

- Today, many institutions, universities and companies have small pyrolysis rigs – its cheaper to contract time on those than build your own facility. Average usage rate of R&D rigs is < 5% - they have time to share with you!
- Use a specialist to design and build equipment if you must have your own – DIY project usually end up missing out on the skills and special features that come with experience.
- Private R&D setups are very, very expensive. Don't do it.
- Do not try and re-invent the wheel. Ever. Many ideas have been consider – look into those first before going into a new area.
- You cannot defy thermodynamics, mass and energy balances and entropy.
- Take the time to learn from others and especially what went wrong. Time and time again I am asked to "fix" equipment that failed to address basic issues. Learn from others.
- Preparation is the key in pyrolysis for small-scale – better preparation reduces errors.

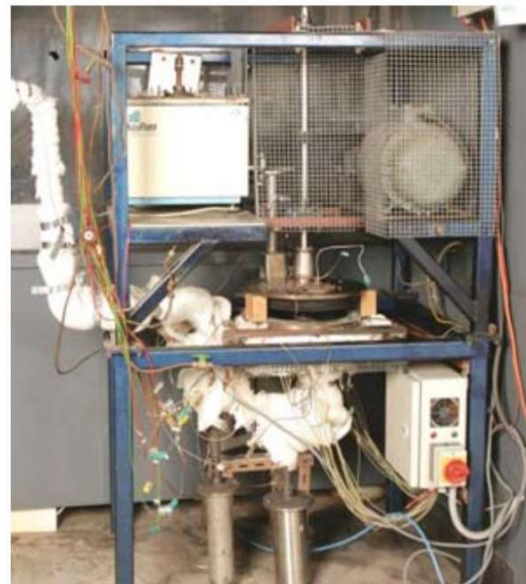
This is not a comprehensive list people that I worked with at Aston, specifically in the Research Group from 1990-1996. I'm sorry if I've missed anyone out from that time from the laboratory:

Anthony Bridgwater  
Geraint Evans [gasification]  
Jimmy Milligan [gasification]  
Robert Hague  
Colin Dick  
Nick Robinson  
Elizabeth Salter  
Ian Tiplady  
Louise Cooke  
Hussam Sheena [HPLC analysis]  
Paul Russell [technician]  
Ian Murkitt [Machinist and fabricator]

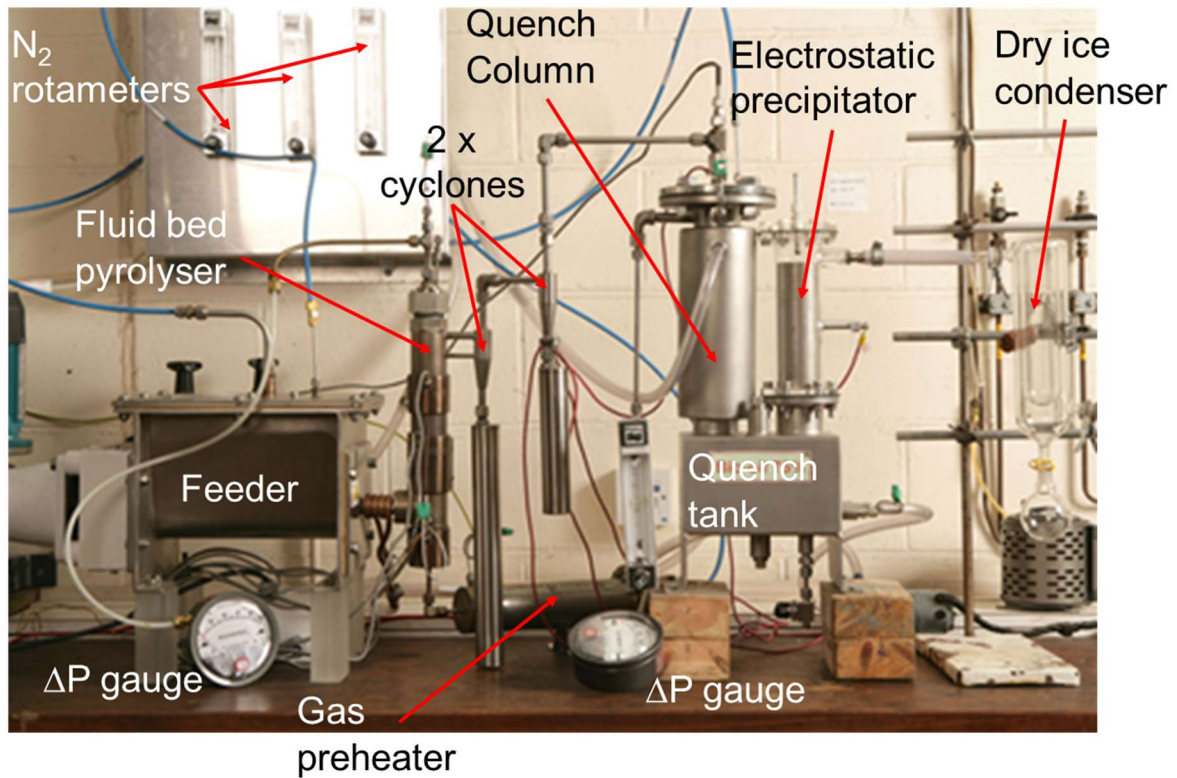
**Aston University Reactors**



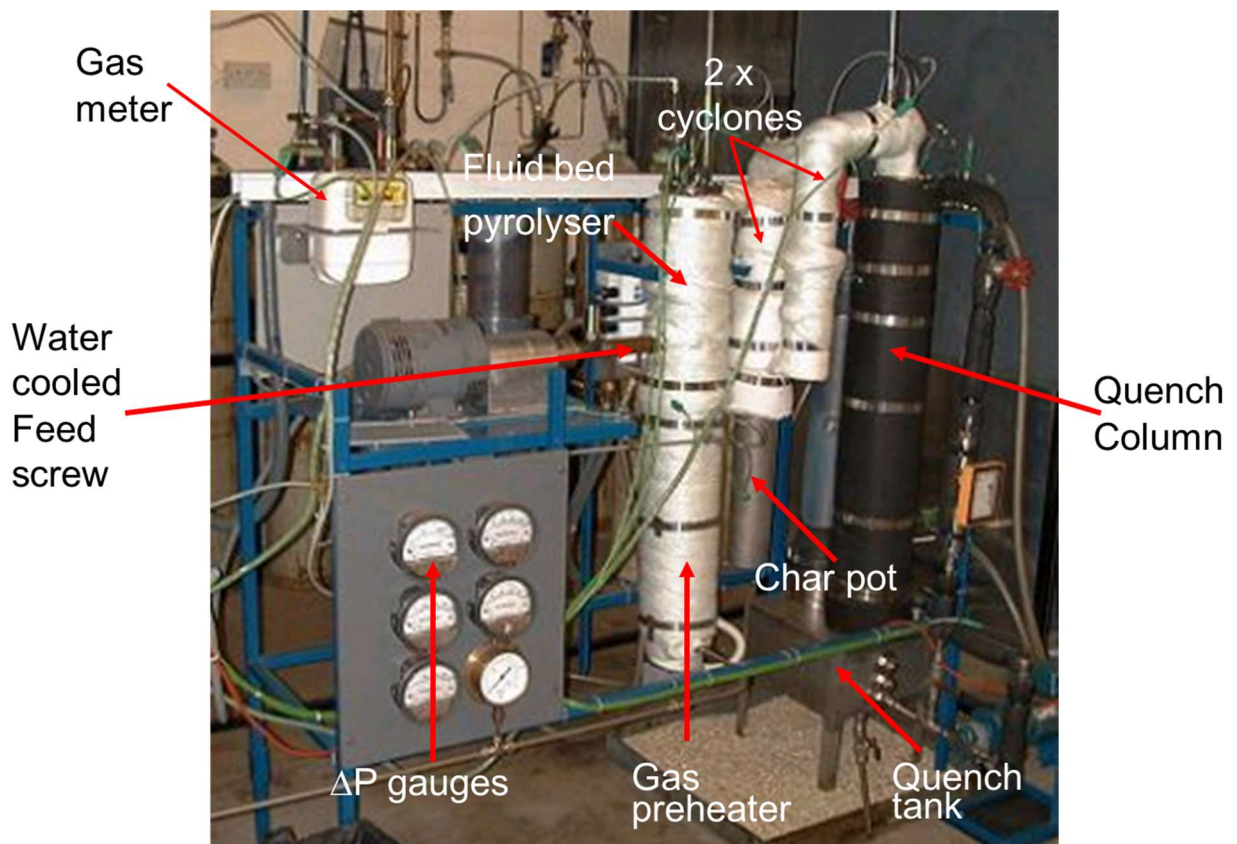
**150 g/h fluid bed pyrolysis reactor**



**5 kg/h ablative pyrolysis rig, Aston University. Version 1. Rotating angled blades**



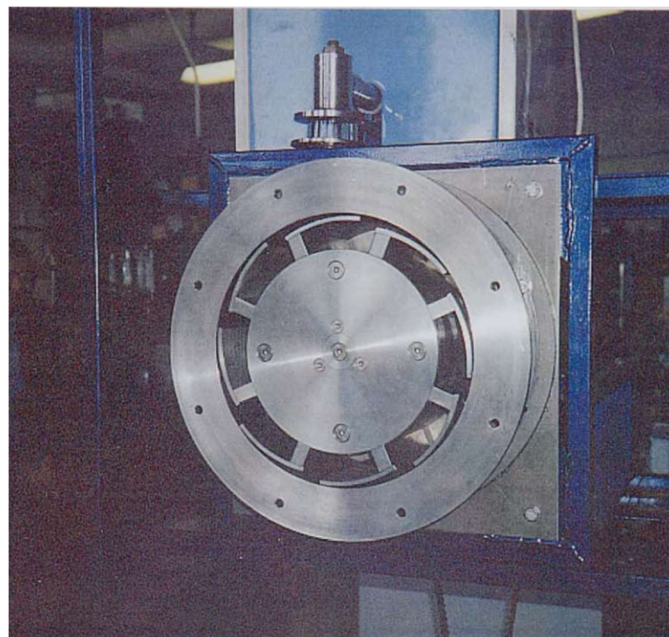
300 g/h fluid bed reactor with liquids quench and electrostatic precipitator.



1.5 kg/h fluid bed reactor with liquids quench and electrostatic precipitator. Version 1



**10-20 kg/h ablative pyrolysis rig. Version 2 [1997 build]**



**Ablative pyrolysis reactor internal cylinder and blades. Version 2.**



**5 kg/h fluid bed reactor with clean gas recirculation [2010] after major upgrades and overhaul**

## EU Contracts worked on or contributed to for Aston University:

1	AIR1-CT92-0216	Improvement of the flash-pyrolysis process and pilot plant for bio-oils upgrading
2	AIR2-CT93-0889	Integrated Chemicals and Fuels Recovery from Pyrolysis Liquids
3	AIR3-CT93-0985	Models for the economic evaluation of selected biomass cultivations as an alternative land use in the European Union
4	AIR3-CT94-1086	Production, treatment and utilisation of bio-oils from pyrolysis for energy and alternative fuels and chemicals
5	AIR3-CT94-1857	Thermal Air Applications (TAIRA)-Pyrolysis Network for Europe –PyNE
6	FAIR6-PL98-4042	Production of slow release nitrogenous fertilisers from biomass fast pyrolysis liquids
7	FAIR-98-3409	PyNe II – Pyrolysis Network for Europe
8	JOR3-CT95-0081	Catalytic Pyrolysis of Biomass for Improved Liquid Fuel Quality
10	JOR3-CT97-0197	Development of Advanced Fast pyrolysis processes for Power and Heat
11	JOUB-CT90-0032-C	Advanced Flash pyrolysis of biomass for liquids
12	RENA-CT94-0070	Development of an internal combustion engine for use with crude pyrolysis oil and an evaluation of associated processes.

## Publications while at Aston University

### Fully refereed-journal

- G.V.C. Peacocke and A.V. Bridgwater, "Ablative Plate Pyrolysis of Biomass for Liquids", Biomass and Bioenergy, Vol. 7, No. 1-6, 1994, p 147-154.  
[https://doi.org/10.1016/0961-9534\(94\)00054-W](https://doi.org/10.1016/0961-9534(94)00054-W)
- G.V.C. Peacocke, E.S. Madrali, A.J. Güell, C-Z Li, W. Fan, A.V. Bridgwater and R. Kandiyoti, "Effect of Reactor Configuration on Yields and Structures of Wood Derived Pyrolysis Liquids: A Comparison between Ablative and Wire Mesh Pyrolysis", Biomass and Bioenergy, Vol. 7, No. 1-6, 1994, p 155-167.  
[https://doi.org/10.1016/0961-9534\(94\)00055-X](https://doi.org/10.1016/0961-9534(94)00055-X)
- G.V.C. Peacocke, P.A. Russell, J.D. Jenkins and A.V. Bridgwater, "Physical Properties of Flash Pyrolysis Liquids", Biomass and Bioenergy, Vol. 7, No. 1-6, 1994, p 169-177.  
[https://doi.org/10.1016/0961-9534\(94\)00056-Y](https://doi.org/10.1016/0961-9534(94)00056-Y)

### Fully refereed-conference

- G.V.C. Peacocke and A.V. Bridgwater, "Design of a novel ablative pyrolysis reactor", Advances in Thermochemical Biomass Conversion, Bridgwater, A.V., (ed.), Blackie Academic and Professional, Glasgow, 1994, p 1134-1150.
- D Meier, A. Oasmaa and G.V.C. Peacocke, "Properties of Fast Pyrolysis Liquids: Status of Test Methods", Developments in Thermochemical Biomass Conversion, Bridgwater, A.V. and Boocock, D.G.B. (eds.), Blackie Academic and Professional, 1996, volume 1, p 391-408.
- J. Lédé, J.P. Diebold, G.V.C. Peacocke and J. Piskorz, "The nature and properties of Intermediate and unvaporized biomass pyrolysis materials", Developments in Thermochemical Biomass Conversion, Bridgwater, A.V. and Boocock, D.G.B. (eds.), Blackie Academic and Professional, 1996, volume 1, p 27-41.
- G.V.C. Peacocke, C.M. Dick, R.A. Hague, L.A. Cooke and A.V. Bridgwater, "Comparison of ablative and fluid bed fast pyrolysis products: yields and analyses", Developments in Thermochemical Biomass Conversion, Bridgwater, A.V. and Boocock, D.G.B. (eds.), Blackie Academic and Professional, 1996, volume 1, p 191-205.

### Non-refereed or partially reviewed

- G.V.C. Peacocke and A.V. Bridgwater, "Ablative Pyrolysis of Biomass", 6th European Conference on Biomass for Energy, Industry and the Environment, Athens, 22-26 April 1991, Grassi, G., Collina, A. and Zibetta, H. (eds.), Elsevier Applied Science Publishers, 1992, p 721-727.
- G.V.C. Peacocke and A.V. Bridgwater, "Ablative Biomass of Pyrolysis for Liquid Fuels", Energy from Biomass Thermochemical Conversion: Proceedings of EC Thermochemical Contractors Meeting, 29-31 October 1991, Gent, Belgium, Grassi, G. and Bridgwater, A.V. (eds.), EEC DGXII, 1992, p. 103-111.
- G.V.C. Peacocke and A.V. Bridgwater, "Ablative Pyrolysis of Biomass for the production of liquid fuels", Biomass for Energy and Industry 7th EC conference, Hall, D.O., Grassi, G. and Scheer, H. (eds.), Ponte Press, Berlin, 1994, p 931-937.

- G.V.C. Peacocke and A.V. Bridgwater, "Ablative Pyrolysis of biomass for the production of liquids in high yields", The 1994 I.Chem.E. Research Event, 1994, I.Chem.E. ISBN 0852953208, p 556-558.
- G.V.C. Peacocke and A.V. Bridgwater, "Advanced Flash (Ablative) Biomass of Pyrolysis for Liquid Fuels", Proceedings of Energy from Biomass Contractors' Meeting, Grassi, G. Moncada, P. and Zibetta, H., CEC DG XII/77/91, Biomass Unit (F/4), 1991, p 294-306.
- G.V.C. Peacocke and A.V. Bridgwater, "Advanced Flash (Ablative) Biomass of Pyrolysis for Liquid Fuels: Progress of JOUB-0032-C", Energy from Biomass: Progress in Thermochemical conversion, Proceedings of the EC Contractors' Meeting, 7 October 1992, Grassi, G. and Bridgwater, A.V. (eds.), EUR 15389 EN, CEC DG XIII, Brussels, 1994, p 31-41.
- M. Palm, J. Piskorz, G.V.C. Peacocke, D.S. Scott and A.V. Bridgwater, "Pyrolysis of Sweet Sorghum Bagasse in the Waterloo Fast Pyrolysis Process", First Biomass Conference of the Americas: Energy, Environment, Agriculture and Industry, Vol. II, National Renewable Energy Laboratory, 1993, NREL/CP-200-5768, p 947-963.
- G.V.C. Peacocke and A.V. Bridgwater, "Production of Liquids in high yields by ablative fast pyrolysis", Biomass for Energy, Environment, Agriculture and Industry, Vol. 3, 8th EC Conference, Chartier, P., Beenackers, A.A.C.M. and Grassi, G., (eds.), Pergamon, Oxford, 1995, p 1749-1756.
- G.V.C. Peacocke, R.A. Hague and A.V. Bridgwater, "Selective Production of Chemicals by Biomass Fast Pyrolysis using two different reactors", The 1995 I.Chem.E. Research Event, 1995, I.Chem.E, Vol. 2, p 1112-1114.
- A.V. Bridgwater and G.V.C. Peacocke, "Biomass Fast Pyrolysis", 2nd Biomass Conference of the Americas, Portland, Oregon, USA, 20-25 August 1995, NREL, publication no. NREL/CP-200-8098, 1995, p 1037-1047.
- A.V. Bridgwater and G.V.C. Peacocke, "Engineering Developments in Fast Pyrolysis for Bio-oils", Biomass Pyrolysis Oil properties and Combustion meeting, September 26-28 1994, Estes Park, Colorado, USA, US DoE, publication no. NREL/CP-430-7215, p 110-127, 1995.
- G V C Peacocke, I.R. Tiplady and A V Bridgwater, "Fast pyrolysis of biomass for the production of liquids", East Midlands Renewable Energy Group Workshop, 22 June 1995, University of Loughborough, 1995.
- I.R. Tiplady, G.V.C. Peacocke and A.V. Bridgwater, "Physical properties of fast pyrolysis liquids from the Union Fenosa pilot plant", Bio-oil Production and Utilisation- Proceedings of the 2nd EU-Canada workshop on Thermal Biomass Processing, Bridgwater, A.V. and Hogan, E.N., CPL Press, Newbury, 1996, p 164-174.
- G.V.C. Peacocke and A.V. Bridgwater, "Ablative fast pyrolysis of biomass for liquids: results and analyses", Bio-oil Production and Utilisation- Proceedings of the 2nd EU-Canada workshop on Thermal Biomass Processing, Bridgwater, A.V. and Hogan, E.N., CPL Press, Newbury, 1996, p 35-48.
- G.V.C. Peacocke, C.M. Dick, R.A. Hague, L.A. Cooke and A.V. Bridgwater, "Comparison of ablative and fluid bed fast pyrolysis products: yields and analyses", Biomass for Energy and the Environment, Proceedings of the 9th European Bioenergy Conference, Chartier, P., Ferrero, G.L., Henius, U.M, Hultberg, S., Sachau, J. And Wiinblad, W. (Eds.), 1996, Pergamon Press, Volume 3, p 1632-1637.