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Bridging the Gap

Boosting GC Productivity

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Content

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- What does boosting GC productivity mean to you?
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Boosting productivity?

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- Removing bottlenecks to make the analysis as efficient as possible, from start to finish
- Can be to increase sample throughput
  - per batch
  - per day/week
  - per analyst
- Improving:
  - Number of samples analysed per instrument
  - Total number of samples reported in a time frame
  - Total number of samples that can be collected for analysis in a day
- Usually results in:
  - Cost savings
  - Overall sample throughput from collection to reporting

Analysis workflow

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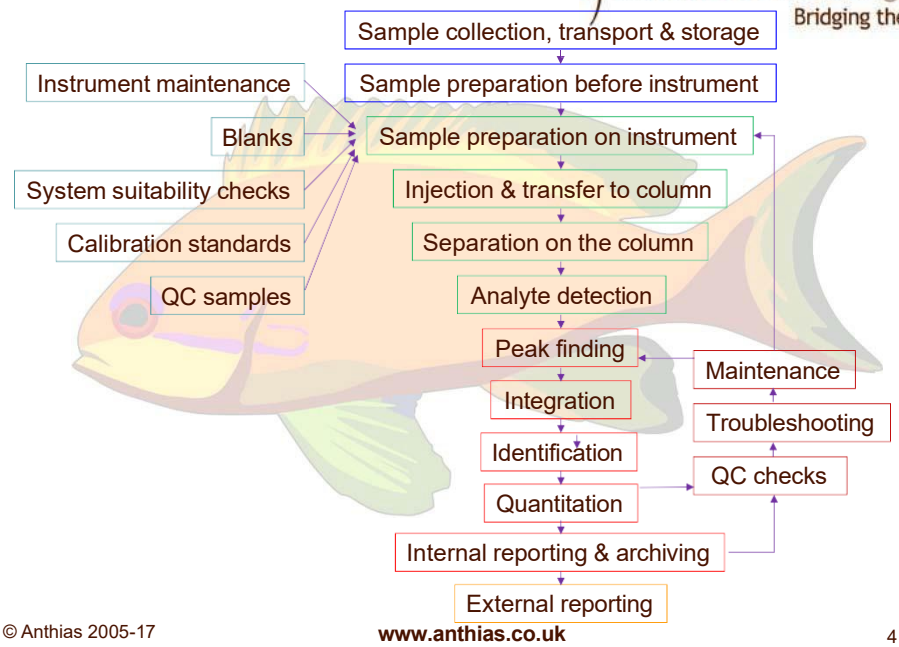

Lean principles

Lean principles can be applied to:

- Sample collection
- Sample transport
- Booking-in of samples
- Sample storage
- Scheduling
- Sample splitting into aliquots for each individual test

Not covered in this presentation as focus is on GC

but

A modern open plan laboratory where all staff can see everything coming can 'boost productivity' too as it creates a 'push' environment

Boosting GC Productivity

Existing method tweaks

Existing method tweaks

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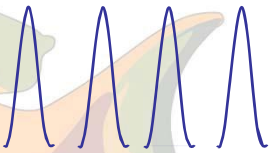
- No hardware changes
- No changes in consumables used
- Examination of the 'electronic' method
  - Instrument acquisition
  - Data analysis
  - Reporting
- Usually:
  - Lots of small tweaks (optimisation of parameters) to have an effect
  - Rarely one tweak has a large effect – but can occur!
- Must:
  - Always consider effect on other parameters & workflow parts
  - Ensure method is robust above all else
- Some are technique, instrument set-up and manufacturer-specific



Cycle time

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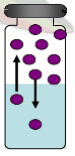
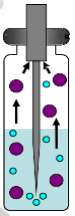
'Time taken from injection to ready for injection' includes:

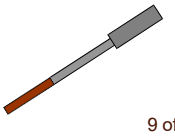
- Analysis time
  - sample injection, separation & detection
- Post-run steps
  - back-flushing, bakeout
- Cool down time
  - location of GC (air flow), lab ambient temp, initial/final oven temp, efficiency of programmable inlet & oven cooling
- Next sample preparation for injection
  - After GC run has finished (e.g. liquid autosamplers)
  - Before previous GC run has completed (e.g. HS, TD, etc.)
- Equilibration times
  - Long enough to ensure instrument stability, but minimal
- Allow margin of error, e.g. cycle time slightly longer
  - Instrument waits rather than prepared sample
  - Summer vs. winter cool-down times
  - All instruments running vs. 1 instrument in use



Sample Prep on Instrument

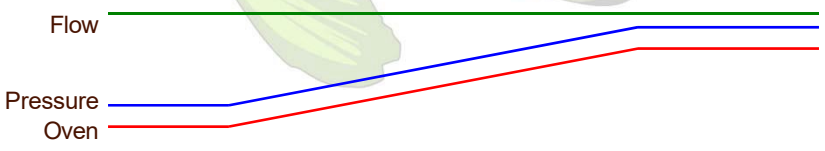
- E.g. liquid autosampler, HS, SPME, P&T, TD
- Using full functionality & optimising current autosampler method saves analyst's time & reduces cycle time
- Compare sample prep. time with GC run time
  - Which is the bottleneck?
  - Revisit method parameter optimisation for bottleneck
    - Ensure method remains robust!
- Ensure next sample is prepared ready to inject when GC comes ready
  - Can be as simple as using a stopwatch to check cycle times then input into autosampler method
  - For short GC runs, can double productivity!





Separation

- Column flow rates
  - Constant flow vs. constant pressure for later-eluting peaks
  - Consider higher flow rates, dependent on application
    - Ensure flow rate is no lower than most efficient flow for gas type & column
    - Higher CF can be more effective at reducing runs times than raising oven temperatures!

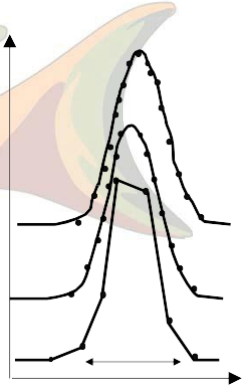


Separation

- Oven temperature program
  - Initial oven temp.
    - Matched to solvent bp for splitless/LVI
    - High as possible for split injection
  - Initial hold time: matched to time taken to transfer analytes to column
  - Ramp rates: matched to separation then compare faster rates
  - Final oven temp.
    - Elute analytes on temp. ramp (use full temp range of column), no final hold time
    - Check inlet temp: only transfer analytes to column, not high MW matrix that needs 'burning off'
    - End run asap, after all compounds transferred to column have eluted

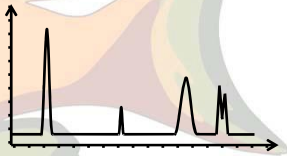
Analyte detection

- Check number of data points across the peak
  - Too high acquisition rate =
    - Lose sensitivity
    - Peaks not smooth
  - Too low acquisition rate =
    - 'Join the dot' appearance
    - Difficult to differentiate co-eluting peaks
- Both cause
  - Difficulties for data analysis software
  - Leading to higher analyst interactions
- Remember, higher quality data
  = easier & faster data analysis



Data analysis

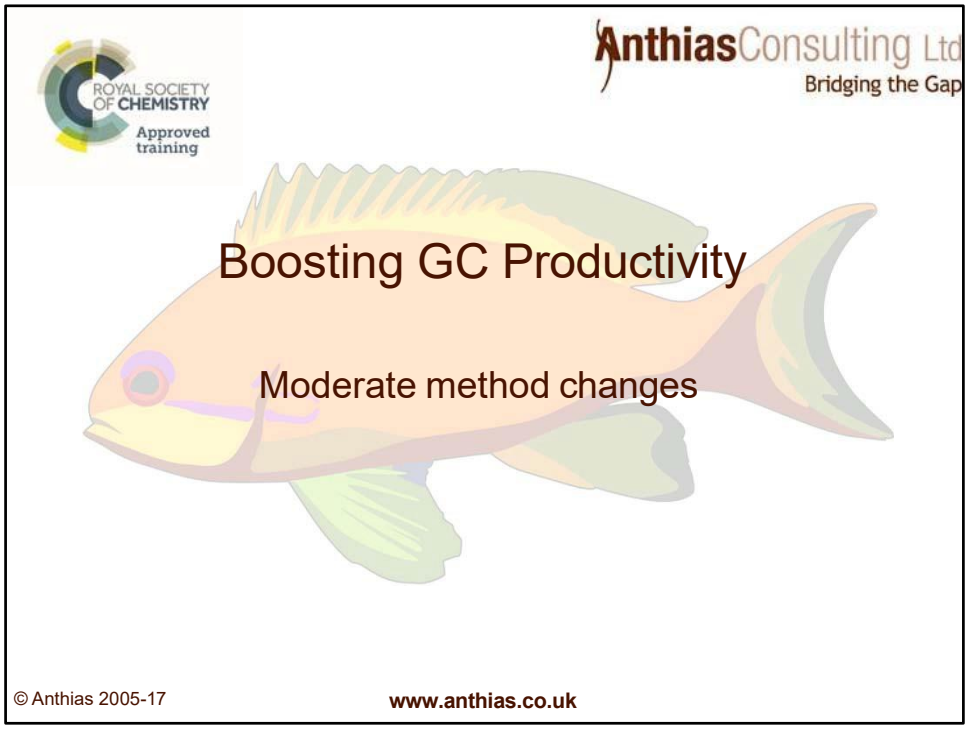
- Different analytes can have different peak shapes
  - Gaussian or tailing
  - Sharp or broad
- Some analytes suffer more/less from matrix effects
  - Retention time shifts
  - Peak shape
  - Broadening effects over time



- Therefore, standard DA method parameters not best for all analytes!
  - Start with values best for majority of peaks
  - Keep note of those requiring manual intervention
  - Optimise parameters for those with recurring problems

Data analysis

- Develop method step-by-step, fully test each step before fully automating
  - Add as much info. into sequence as possible to be used by DA method & reporting
  - Add as much info. into DA method as possible, to be used by reporting
- Remember
  - Data analysis method will take months to fully optimise
  - Need to test with many samples of differing matrices & amounts
  - Fully optimised DA parameters = possibility of robust DA automation = confidence in results with minimal false positives & negatives = HUGE time savings for routine analyses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Moderate method changes
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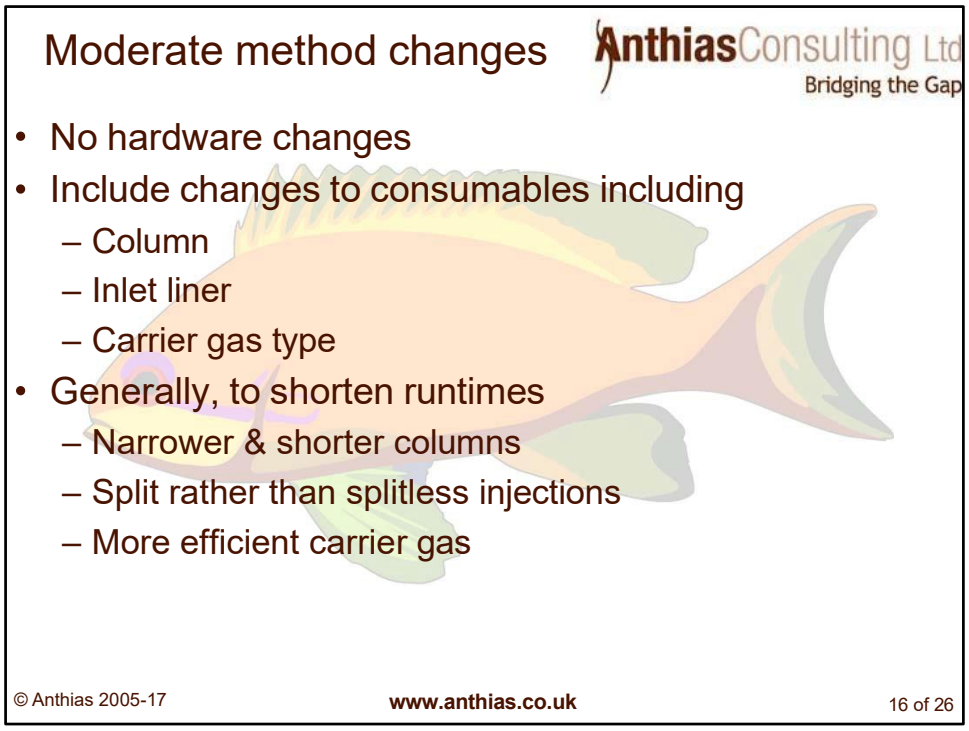
Moderate method changes
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• No hardware changes
• Include changes to consumables including
– Column
– Inlet liner
– Carrier gas type
• Generally, to shorten runtimes
– Narrower & shorter columns
– Split rather than splitless injections
– More efficient carrier gas
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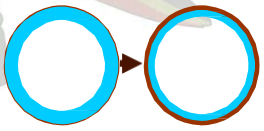
Injection & transfer to column

- Needs to be robust
- Needs to be fast
- Match liner to:
  - Injection technique for better transfer
  - Vapour volume (50-75% of liner volume)
    - Avoids problems, like exceeding liner volume
    - Smaller volumes = shorter splitless times
      - RoT: 2x flushes of liner volume
    - Shorter splitless time = shorter oven initial hold time = shorter run time
    - But, ensure splitless time is long enough = robust method

Separation on the column

- Hydrogen faster & more efficient than helium
  - As good as, if not better separations in shorter time
  - Can cause lower sensitivity & not suitable for some applications!

- Stationary phase
  - Investigate other phases: some analytes elute at lower temperatures = less cool-down time



- Stationary phase thickness
  - Just thick enough!
  - Excess stationary phase = longer to elute & higher bleed = more frequent maintenance

Separation on the column

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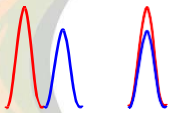
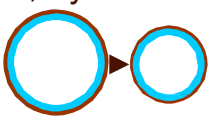
- Column length
  - Shorter column = shorter run time
  - Half the length ≠ half number of theoretical plates, therefore suitable for many applications!
- Column i.d.
  - Narrower i.d. = more efficient separations
  - Can use higher flow rates = shorter run time
  - Usually shorter in length too = shorter run time
  - Caution: lower capacity = use split injection
    - saves time too (transfer time & initial oven temperature)
  - Doesn't mean a jump to a 0.1 mm i.d., try 0.15 or 0.18 mm!





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Major method upgrade

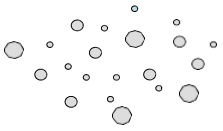
Major method changes

- Introduce a different way of analysing the sample
- Must be:
  - Robust
  - Fit-for-purpose
- Can include instrument hardware changes
  - Autosampler: robotic
  - Inlet: PTV/MMI
  - Column oven: faster heating/cooling like LTM
  - Detector: more selective detectors, e.g. MS/MS

Offline/online sample prep

- Introduce a faster, more effective sample extraction method
  - Automation of existing manual method before the GC
    - E.g. SPE system
  - Miniaturisation & automation on the GC
    - E.g. LLE, derivatisation
  - Automation of certain steps through the GC, e.g.
    - Solvent evaporation through PTV/MMI
    - Addition of IS



Injection & transfer to column

- Large volume injection = automated method for evaporating excess solvent & concentrating sample
- Can be used to:
  - Replace manual solvent blow-down step
  - Enable miniaturised automated sample prep method to be injected
  - Hyphenating with other sample prep techniques
- All of which can increase productivity

Summary

- Boosting productivity can be taken:
  - As small method tweaks to ensure the current method is as efficient as possible
  - More investment can be made to fully optimise the consumables used in the method to boost productivity
  - An overhaul of the method, with potentially new hardware
- The best productivity boost is:
  - A robust analysis method producing high quality data
    - Less re-runs, less troubleshooting
  - A fully optimised data analysis method using all tools within the software, with the least analyst interaction to produce excellent results

Final word

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With dirty samples the matrix has to be dealt with somewhere!

- Through:
  - Sample preparation (automated or manual = time & consumables)
  - Sample introduction (stays in liner = maintenance)
  - Backflushing from column (= time & potential column damage)
  - Selective detection (but still dirties the detector = maintenance throughout system)
- Where is the fastest, cheapest & most efficient place to remove it?
- Which produces the most robust method?
  - Giving better LODs, precision & bias?
- Which gives a robust method & runs on minimum routine maintenance protocols?
  - Maintenance = instrument down time

All has an effect on productivity – a matter of determining which has the least effect for the application & the laboratory!

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Thank you for staying and listening!

Also to my colleagues at Anthias Consulting
Dr Taff Morgan & co. at The Open University

Any questions?

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