EST 1892 LSBU

Can fingermarks survive exposure to corrosive substances?

Forensic Capability Network Research Festival

7th September 2021

Dr Steve Bleay, Ashlyn Masterson, Afraaz Nazir

London South Bank University

Overview

- Corrosive substance attacks
- Aims of the research
- Experimental approach(es)
- Results
- Conclusions
- Further work

Corrosive substance attacks

Remains an issue despite recent legislation controlling sales of concentrated acids and alkalis

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Women burned in Carfin 'corrosive substance' attack

7 June

Two women have suffered serious burns after a corrosive thrown at them in North Lanarkshire.

They were in a house in Carfin when two men arrived in a s after midnight, smashed a window and threw the substanc

The women, aged 21 and 42, were taken by ambulance to Hospital for treatment and later released.

The car believed to have been used was later found burnt South Road, Motherwell.

Police are appealing for information about the attack whic Motherwell Road.

Det Sgt Jim Williamson of Wishaw CID said: "We are still w the motive surrounding this attack, however, we believe th attack.

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Man severely injured in Slough corrosive substance attack

27 January

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'Corrosive substance attack' near Manchester primary school investigated

25 September 2018

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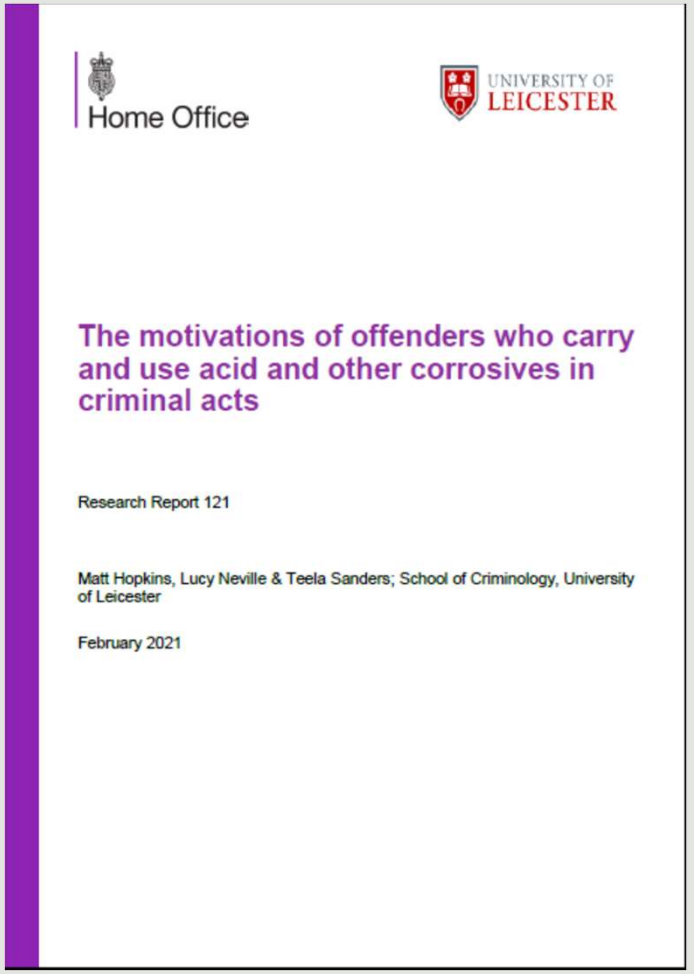
Corrosive substance attacks

- A Home Office-commissioned report into corrosive substance attacks has been recently published which gives the most comprehensive information on such attacks in the UK to date
- Research included review of 648 police case files dealing with offences involving corrosive substances
- Interviews with conducted with convicted offenders that had used corrosive substances
- Consultation with subject matter experts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The motivations of offenders who carry and use acid and other corrosives in criminal acts

Research Report 121

Matt Hopkins, Lucy Neville & Teela Sanders; School of Criminology, University of Leicester

February 2021

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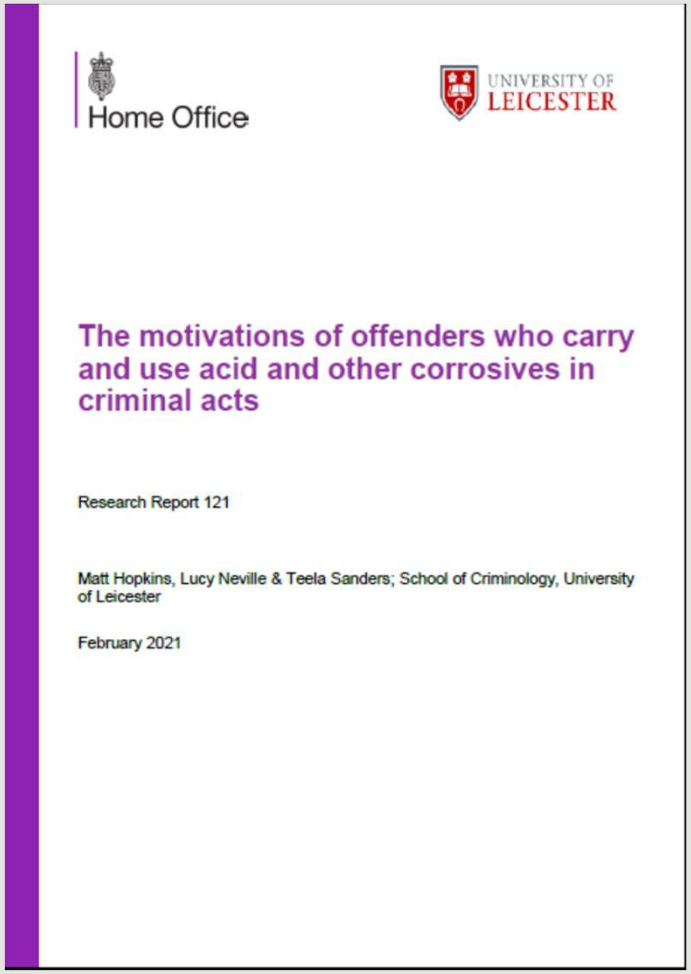
Corrosive substance attacks

- The offences associated with corrosives were categorised in four main crime types
  - robberies,
  - burglaries,
  - violence against the person offences
  - others.
- The highest proportion of offences where corrosive substances were used was violence against the person (77%) and robberies (18%)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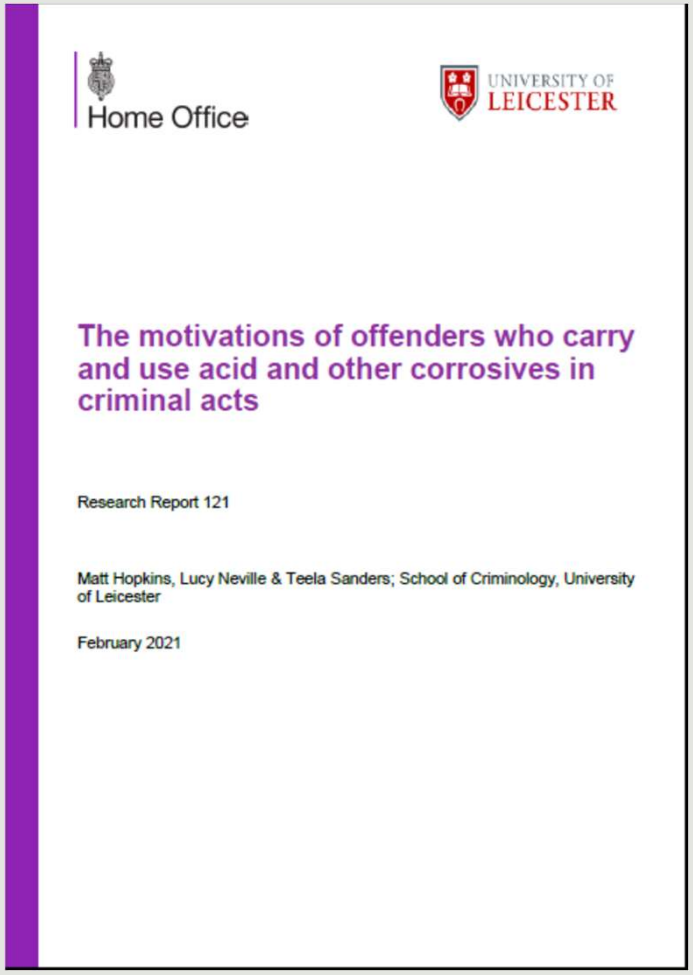
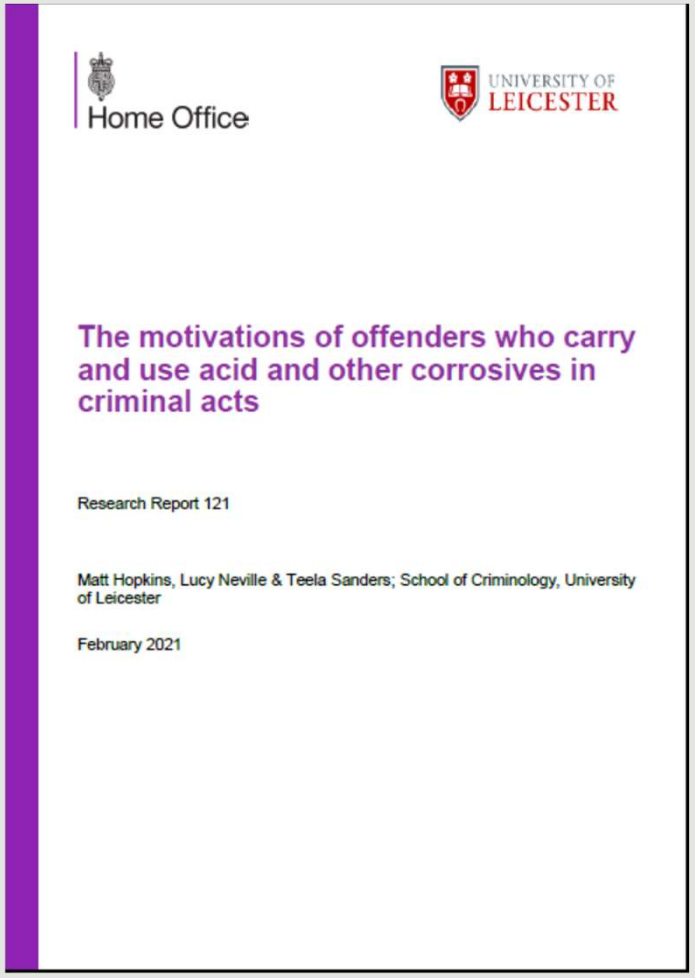
Corrosive substance attacks

- Looked at victim/suspect demographics
- Victims and suspects were most likely to be male (72% and 88% respectively) - contrasts with some other countries where victins are mostly female
- Most between the ages of 16 to 24
- Suspects under the age of 24 were most likely to use substances that are described as acid/ammonia or noxious substances
- Suspects over 24 more likely to use substances described as household corrosives.



Corrosive substance attacks

- Level of injury sustained by victims
- Injuries described as ‘moderate’ in 65% of cases.
- 8% of cases resulted in no injury
- 27% leading to a serious injury to a victim.
- Dependent on corrosive used - In cases where acid was used, 52% resulted in a serious injury as did 21% where ammonia was used.
- Other research suggests under-reporting of such offences….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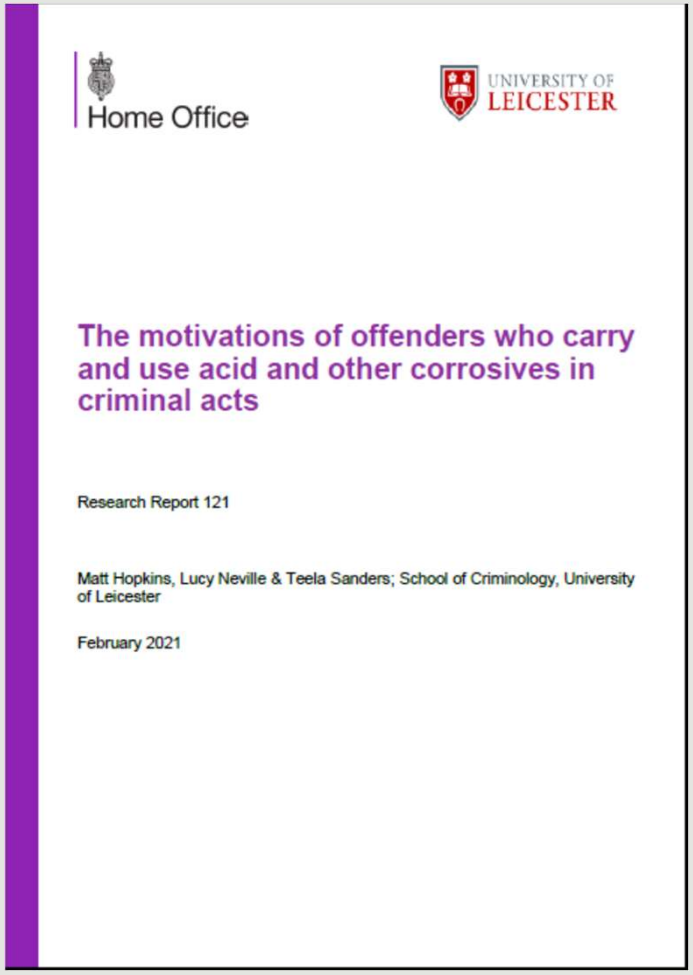
Corrosive substance attacks

- Some of the reasons given for using this form of weapon:
  - The ease of availability
  - Perceived ‘low-risk’ of possessing corrosives
  - Ease of disguising possession
  - Low financial costs
  - The need for self-protection
  - To enhance criminal and street reputation / self-presentation
  - Weapon readiness/speed
  - Instant visual incapacitation of victims
  - Putting physical distance between an offender and victim
  - Silent to use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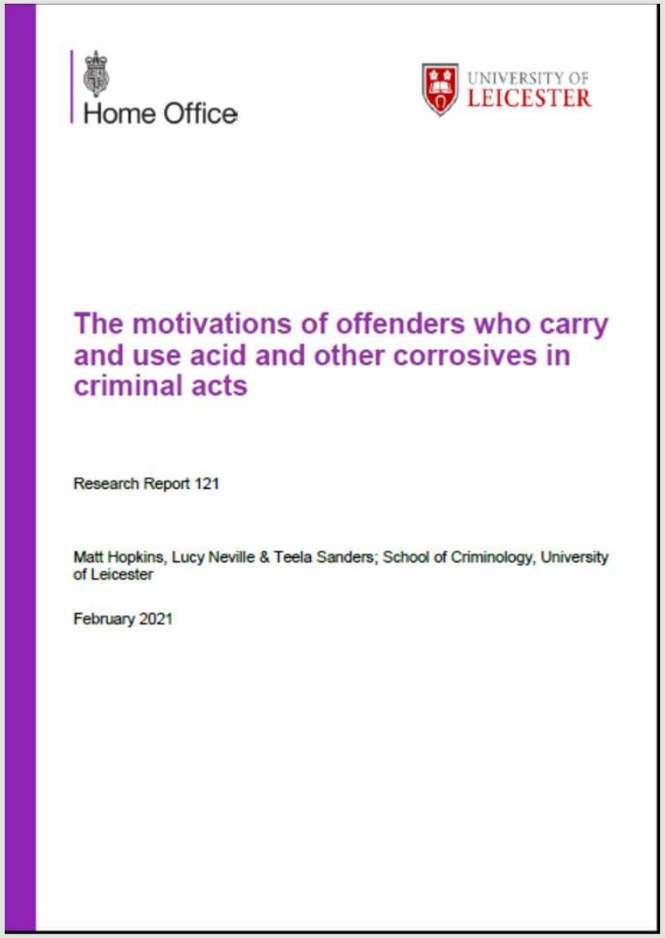
Corrosive substance attacks

- UK trends:
- household products (such as bleach) were the most commonly used corrosive, followed by ammonia (32%), then corrosives labelled as acids/alkalis.
- Bleach 35%, Ammonia 32%, Acid 15%, Noxious substance 11% other 7%
- USA – alkalis more common, extracted from other cleaning agents
- Sulphuric acid sold as liquid in other countries
- Acids used when actual harm intended rather than threat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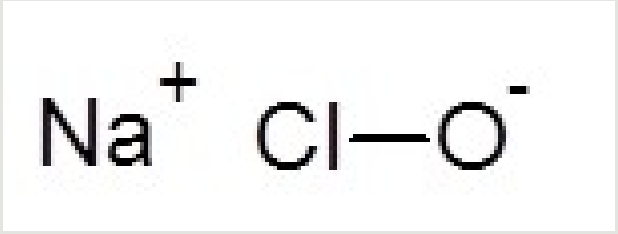
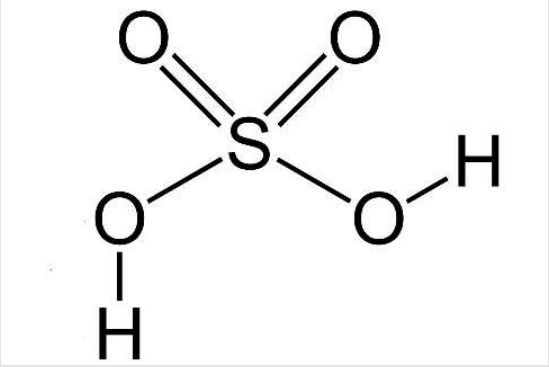
Corrosive substance attacks

- Sodium hypochlorite
- The active constituent in most bleaches
- Also used as patio cleaner, swimming pool cleaner, mould and algae remover…



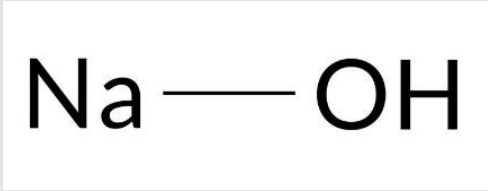
Corrosive substance attacks

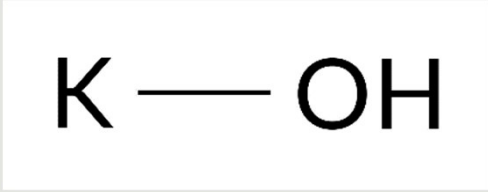
- Sulphuric acid
- Used as the acid in car batteries
- Also found in some brands of drain cleaner



Corrosive substance attacks

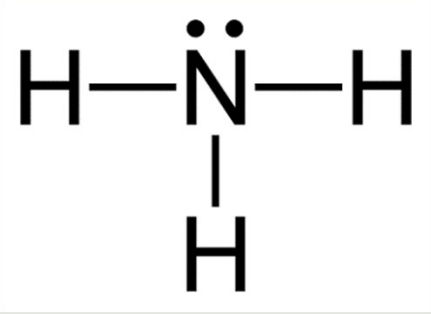
- Potassium and sodium hydroxide (lye and caustic soda)
- Can be used as solid crystals for unblocking sinks and in liquids/gels/mousses for degreasing surfaces





Corrosive substance attacks

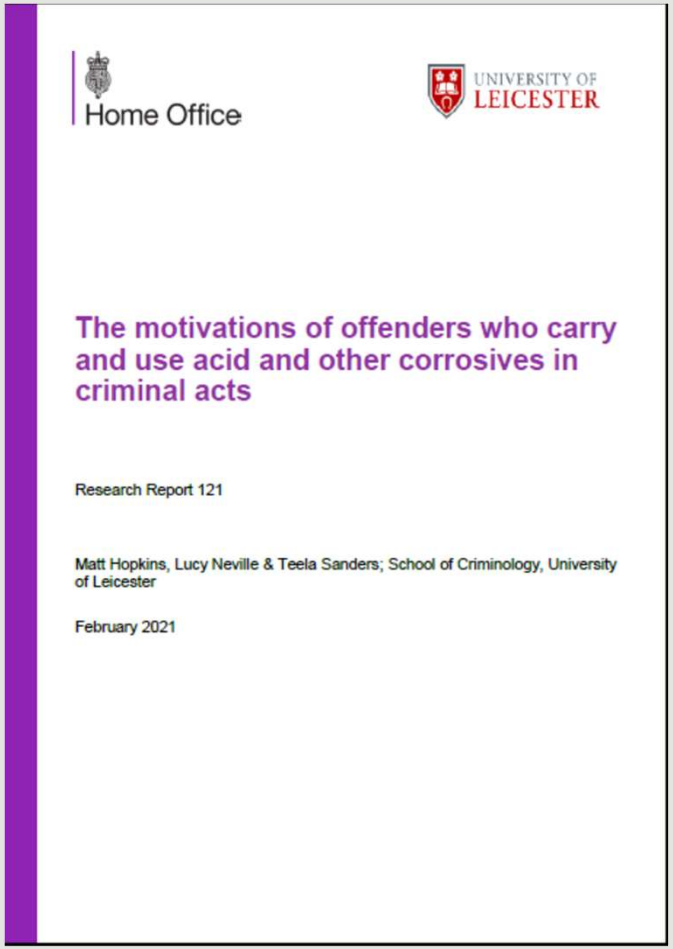
- Ammonia
- Glass/window cleaning products



Corrosive substance attacks

- The most popular method of carrying corrosive substances was in a bottle
- Water bottles and sports drink bottles were the most commonly mentioned transport vessels as they blended in and could be readily available for use.

- Discussions with police force laboratories indicate that glass atomisers may also be used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Corrosive substance attacks

- Different types of bottle capable of delivering a stream of liquid at a distance
- Made from different materials (typically plastic, glass)

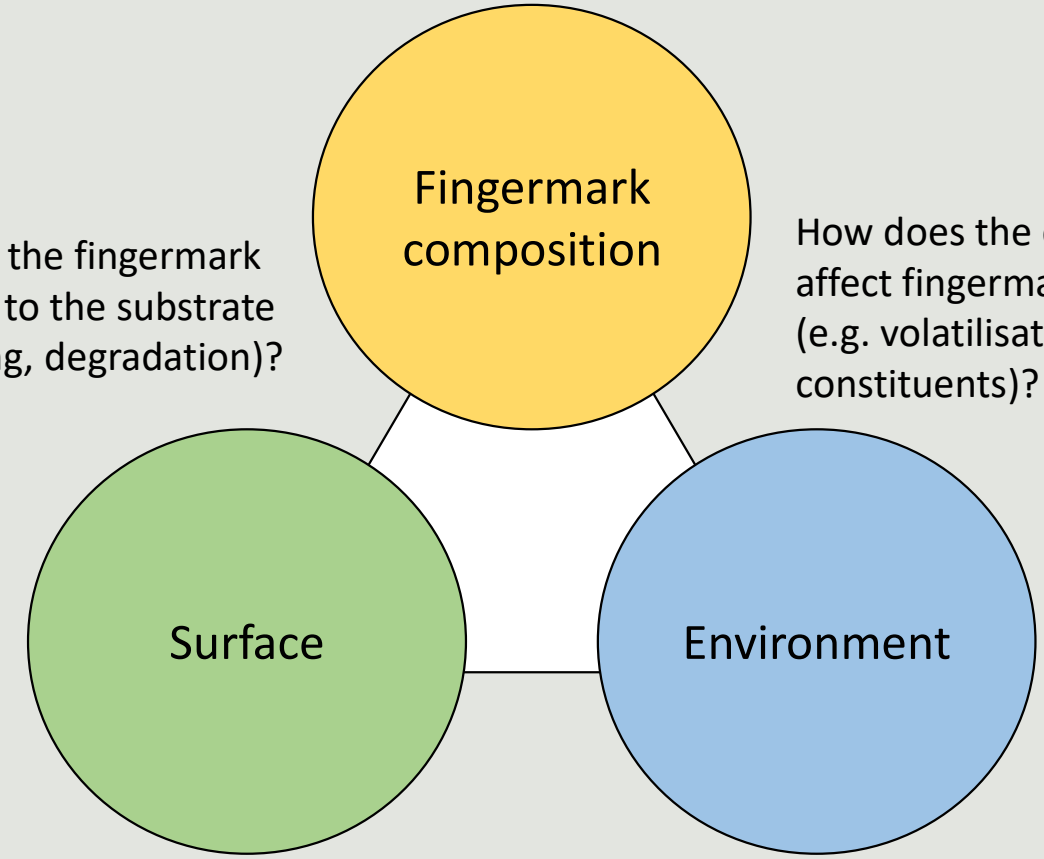
Aim of the research

- Articles used in conducting corrosive substance attacks are received into police laboratories
- There is currently no guidance for how to treat such items
- Lack of knowledge about what types of forensic evidence can be recovered

Aim of the research

- Can forensic evidence survive exposure to corrosive substances?
- If so, which processes remain effective in detection/recovery?
- Initial focus on fingermarks

The Triangle of Interaction



What does the fingermark deposit do to the substrate (e.g. etching, degradation)?

How does the environment affect fingermark chemistry (e.g. volatilisation, dissolving constituents)?

Does the environment affect the substrate (e.g. corrosion, oxidation)?

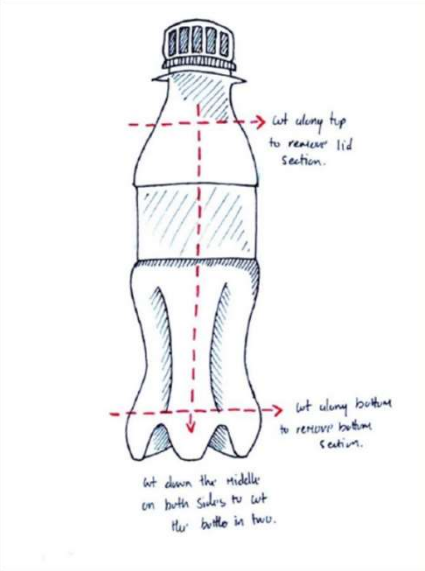
…… + time

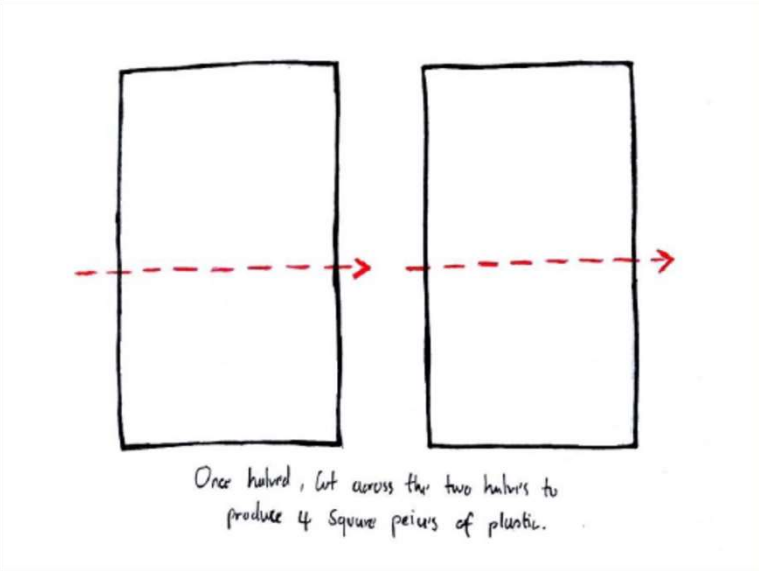
Experimental approaches

- Corrosive substances are an exposure environment that has not been extensively studied before
- LSBU internally funded feasibility study
- Final year BSc project
- Personal research
- LSBU summer internship

Initial study

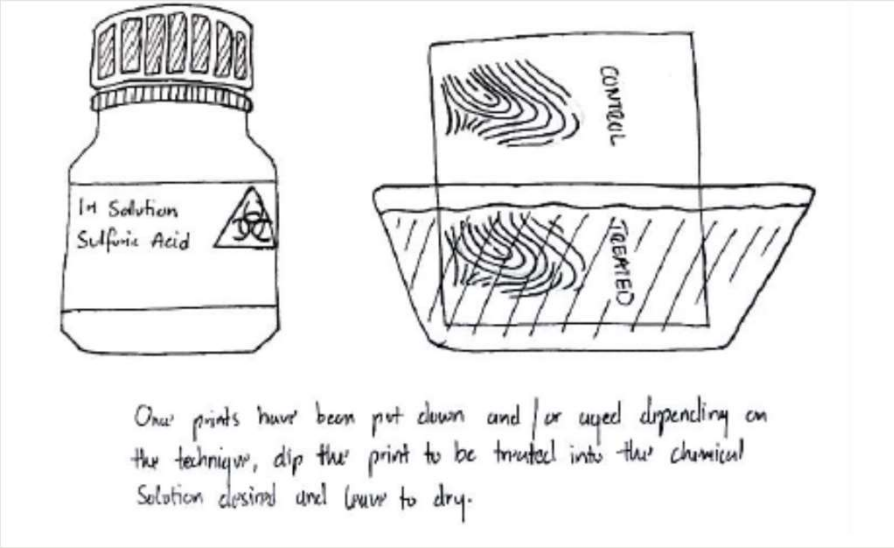
- BSc Final Year project (Ashlyn Masterson)
- Using PET bottles from sport drinks
- Cleaned and cut to give sections with smooth regions for fingermark deposition





Initial study

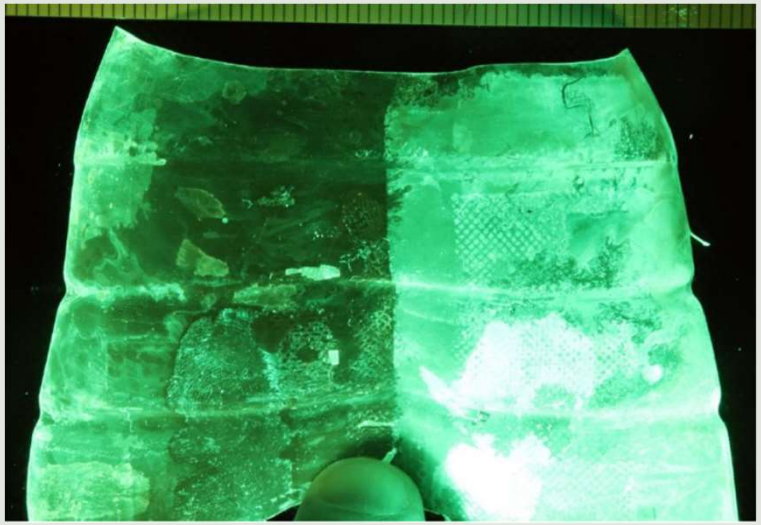
- Used Sulphuric acid, potassium hydroxide, bleach
- Concentrations of 0.01M, 0.1M, 1M
- Different time periods between deposition and exposure
- Development using superglue fuming/BY40, and carbon-based powder suspension



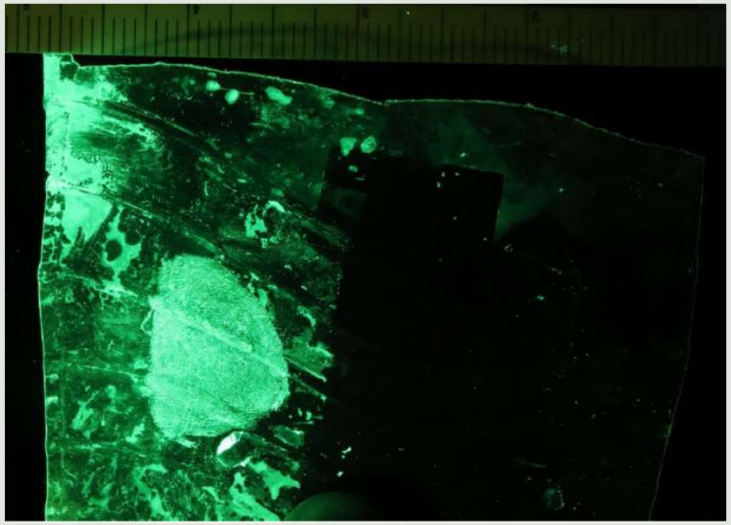
Initial study

- Exposure to corrosive substances generally destructive to fingermarks if superglue/BY40 used as developer
- Differences in background development depending on corrosive substance used

1M KOH



0.1M Bleach



1M H2SO4

Initial study

- Fingermarks developed using powder suspension less detrimentally affected by exposure to corrosive substances
- Trends in background development reversed from case observed with superglue fuming

0.1M H_2SO_4

1M Bleach

0.01M KOH

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Initial study

- Demonstrated that it was possible to detect fingermarks after exposure to corrosive substances in some situations, justifying further study
- In general, increasing concentration was more detrimental
- Alkali exposure (KOH) more damaging than acid exposure (H_2SO_4)

Main study

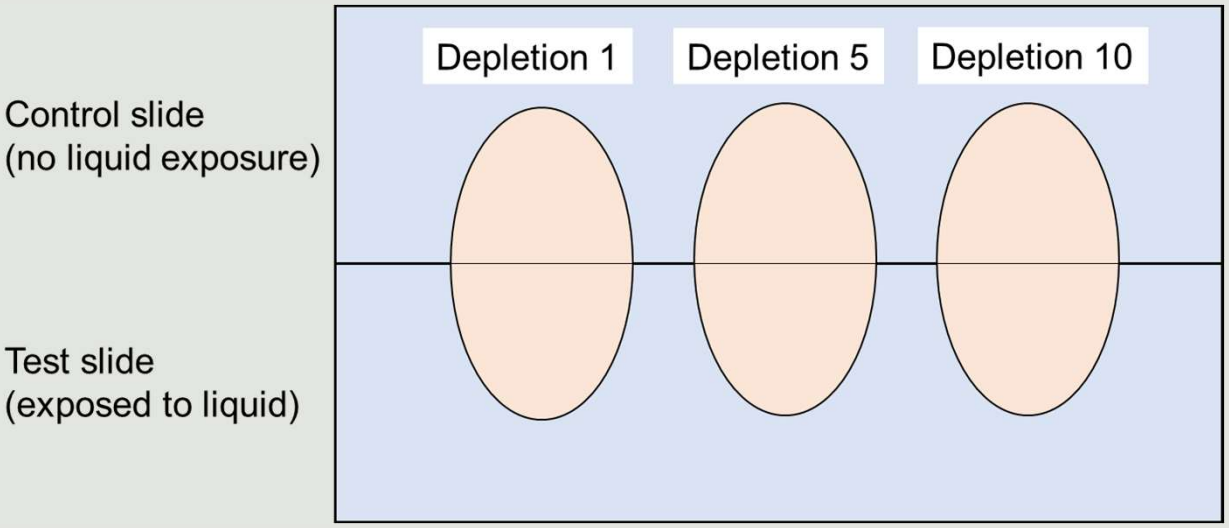
- Extend study to fingerprint depletions
- Extend range of substrates used
- Extend range of fingermark visualisation processes investigated
- Increase concentration of corrosive substances
- Use of samples of base material rather than bottles (increased consistency)

Main study

- Testing materials typical of corrosive substance containers
  - Glass, PET, paper (labels)
- Trial of processes known to continue to develop fingermarks after water exposure
  - VMD, Powders, Powder suspensions, Physical developer, Oil Red O

Main study

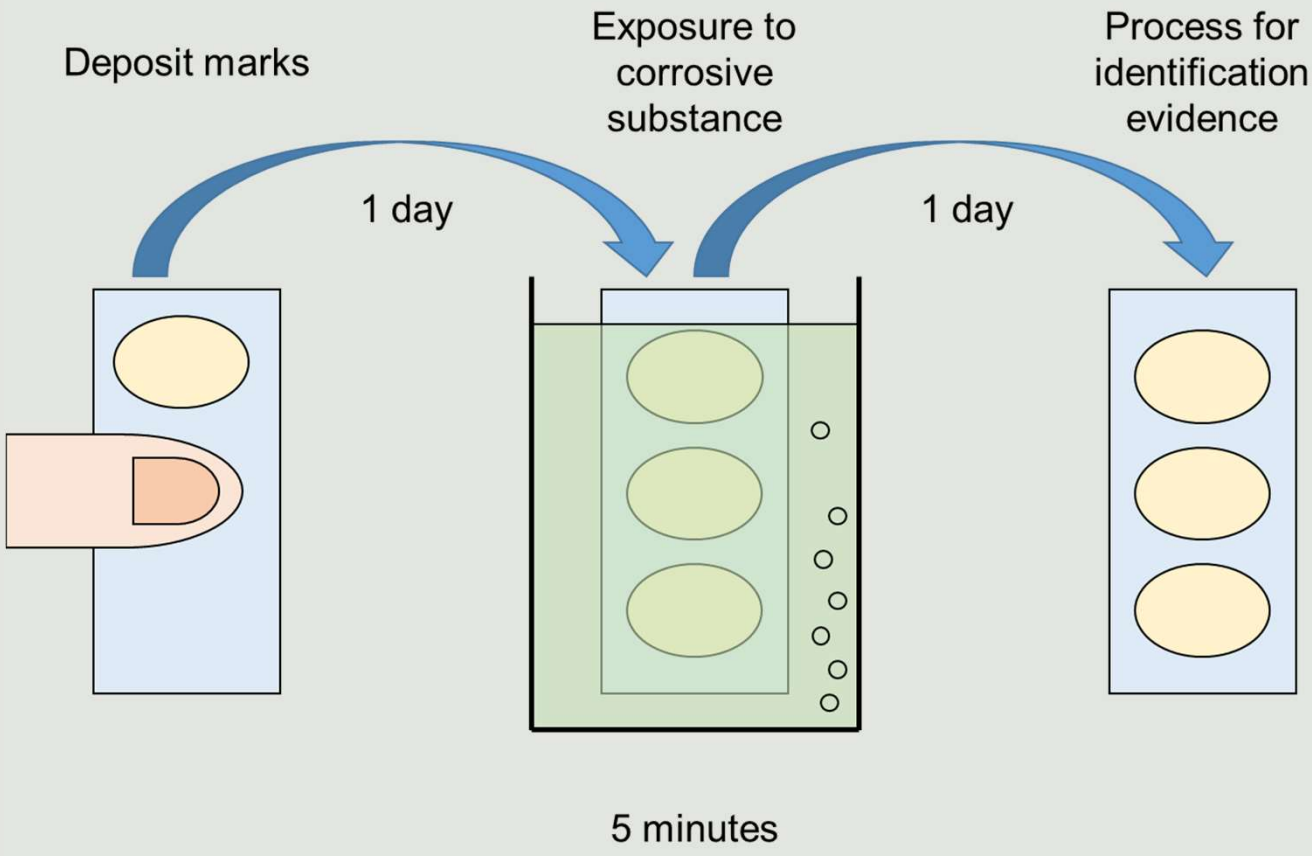
- Deposition of marks 1, 5 and 10 in depletion series across boundary between two slides
- Most work used 4M concentrations of sulphuric acid and potassium hydroxide



Main study

- Corrosive substances selected to represent an acid and an alkali at concentrations equivalent to battery acid
  - 4M Sulphuric acid (H_2SO_4)
  - 4M Potassium hydroxide (KOH)
  - Distilled water (as reference)

Main study

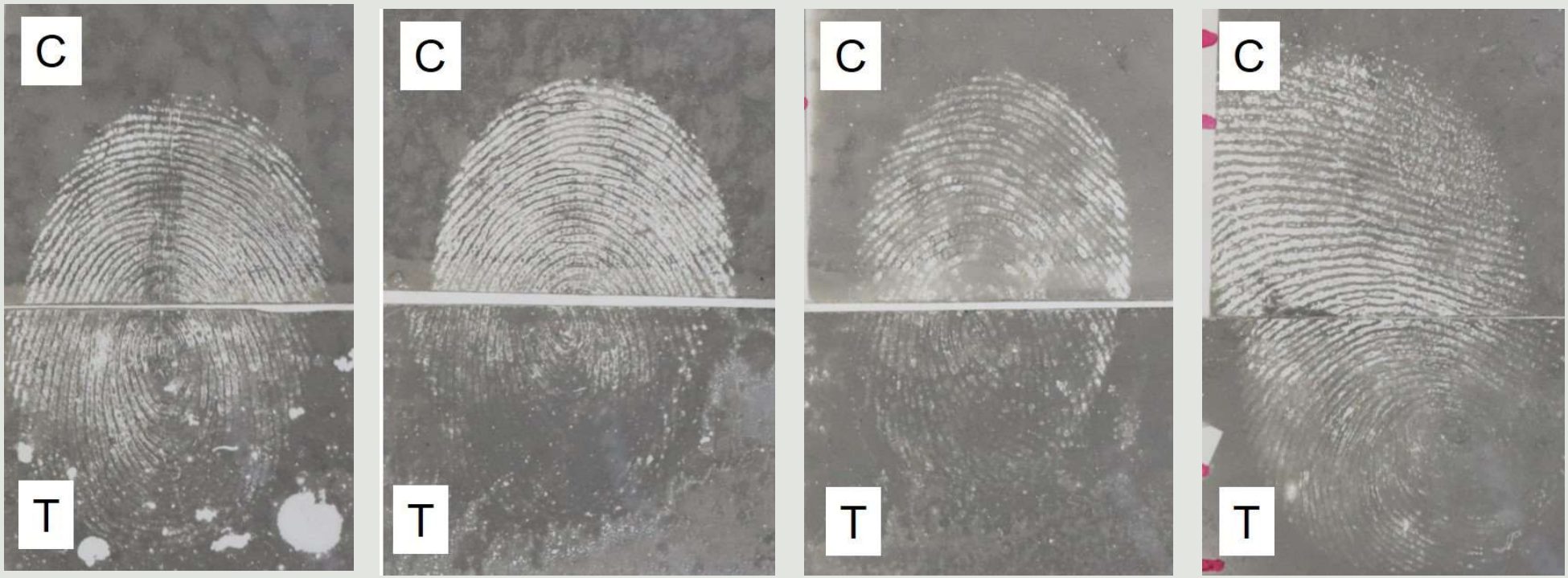

Deposit marks
Exposure to corrosive substance
Process for identification evidence
1 day
1 day
5 minutes

Main study

- Laboratory set-up

Main study

- Gold/zinc VMD on glass after exposure to sulphuric acid (10th depletion)



4M 2M 1M Purified water

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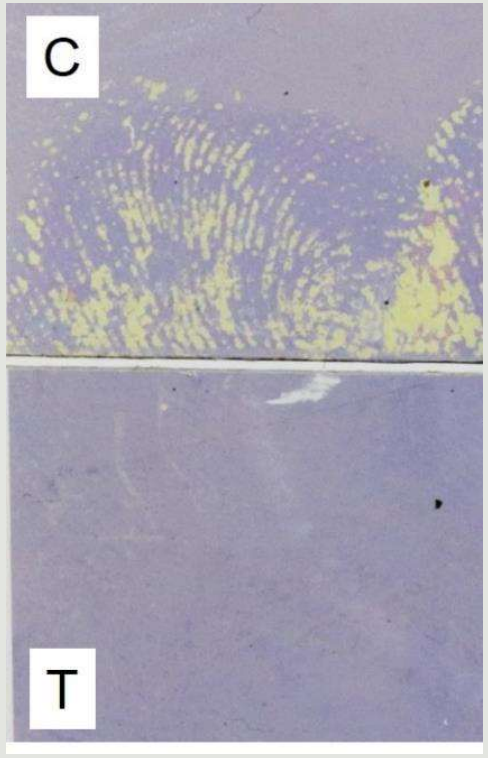
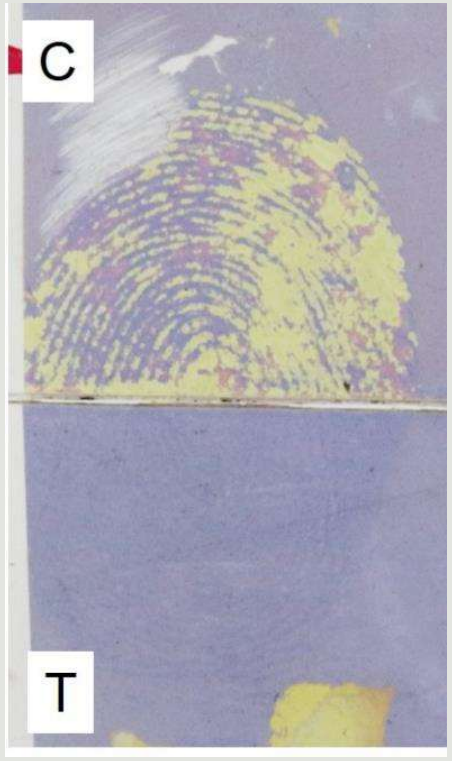
Main study

- Silver VMD on PET after exposure to potassium hydroxide (10th depletion)

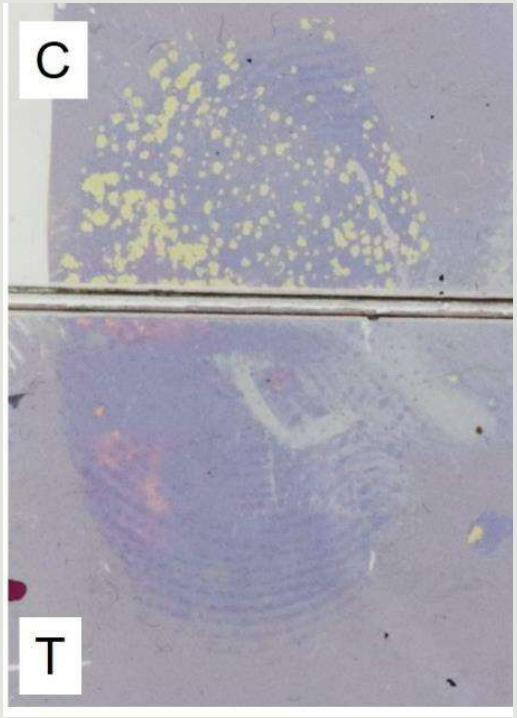


4M

2M



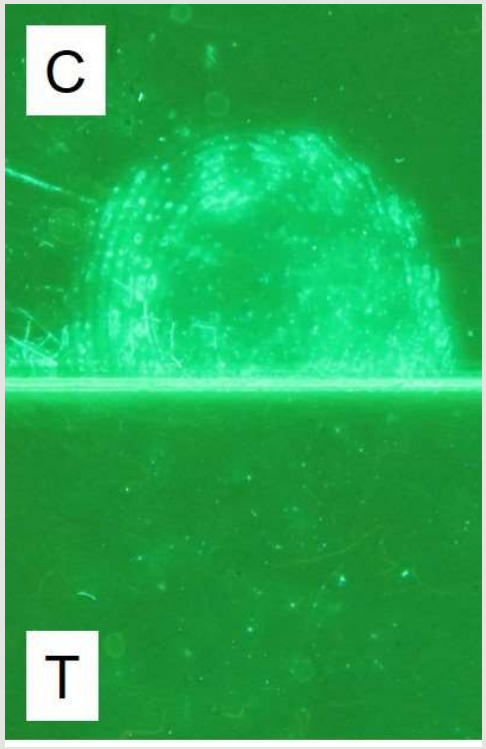
1M



Purified water

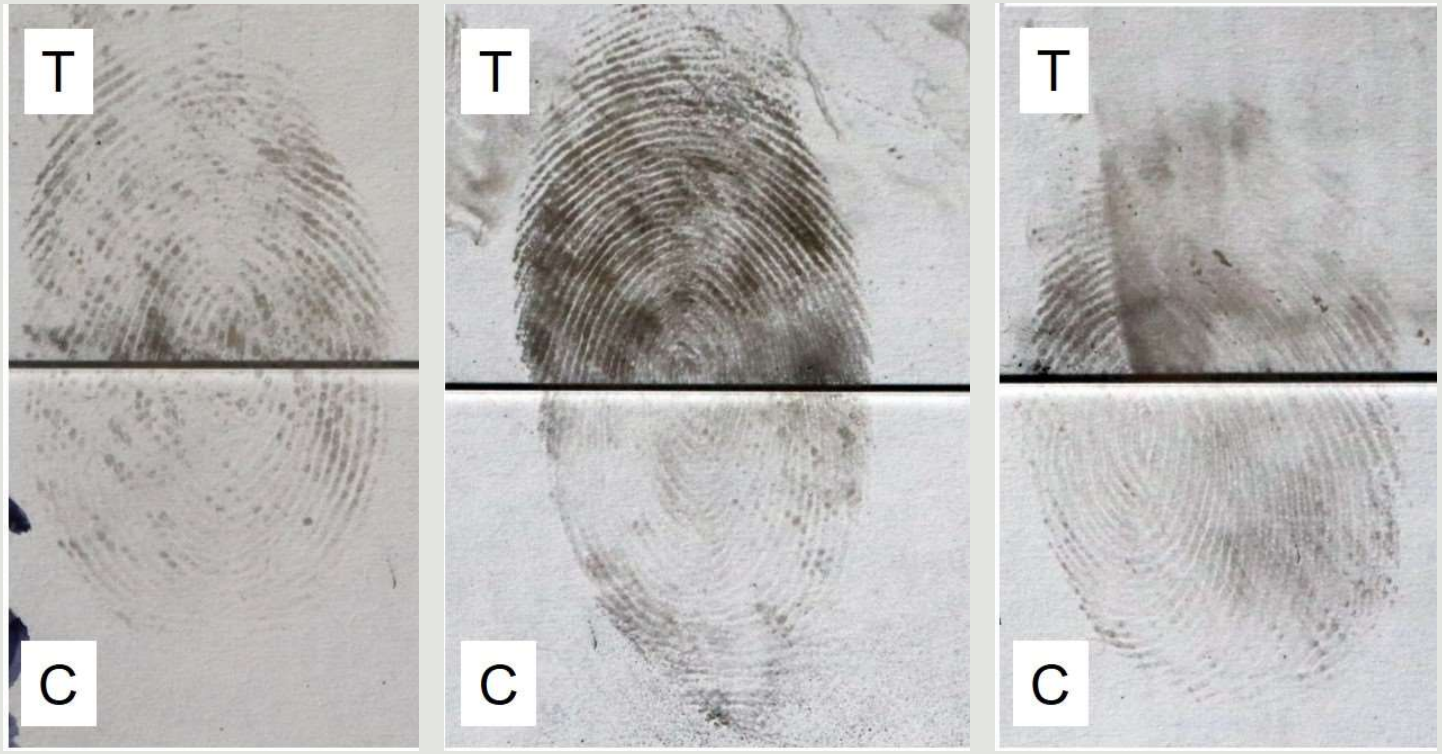
Main study

- Superglue fuming/BY40 – no development after any liquid exposure
- Solvent Black 3 – poor development generally, but potassium hydroxide most detrimental



Main study

- Iron oxide-based powder suspension possibly enhanced by acid exposure, alkali more detrimental



Purified water | 4M H_2SO_4 | 4M KOH

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Main study

- Black magnetic powder – some marks developed but less effective than other processes

Purified water

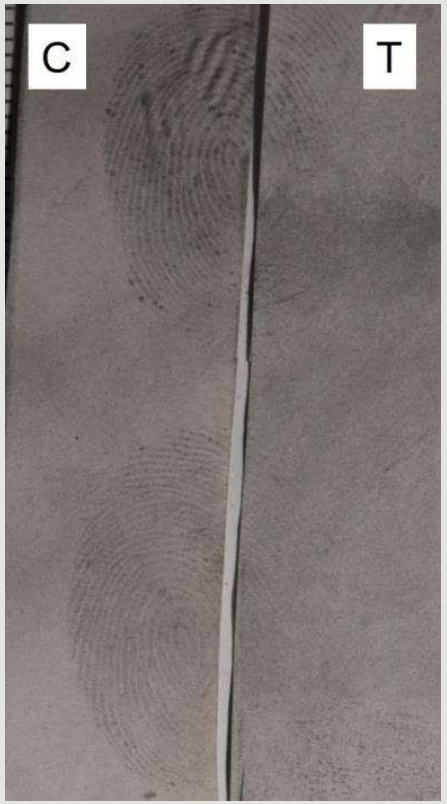
4M H_2SO_4

4M KOH

Main study

- Physical developer – some effect of corrosive substances but can still develop marks

Purified water



4M H_2SO_4

4M KOH

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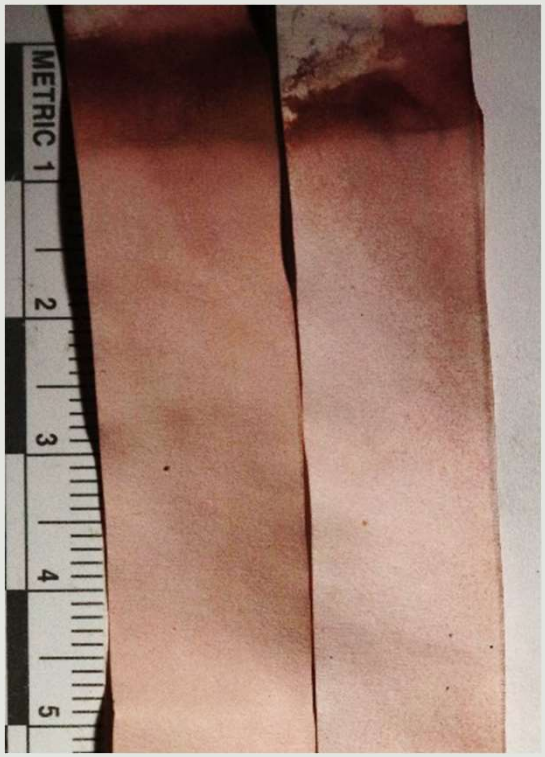
Main study

- Oil Red O and Iodine ineffective after liquid exposure



Purified water

4M H_2SO_4

4M KOH

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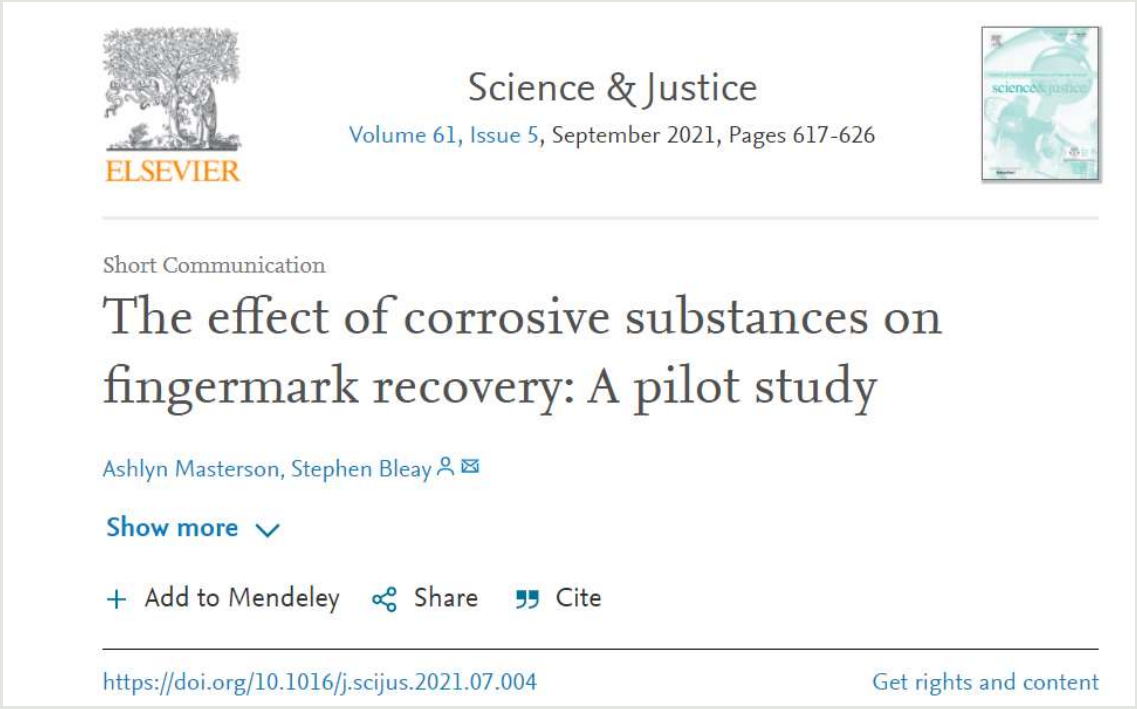
Main study

- Confirmed that fingermark recovery was still possible on all surfaces studied after exposure to corrosive substances
- Alkalis again found to be more detrimental than exposure to acids
- Vacuum metal deposition found to be most effective on non-porous surfaces, although powder suspensions a reasonable alternative
- Physical developer capable of developing marks on paper exposed to corrosive substances

Main study

- Recently published as a short communication in Science & Justice



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Science & Justice

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Short Communication

The effect of corrosive substances on fingermark recovery: A pilot study

Ashlyn Masterson, Stephen Bleay

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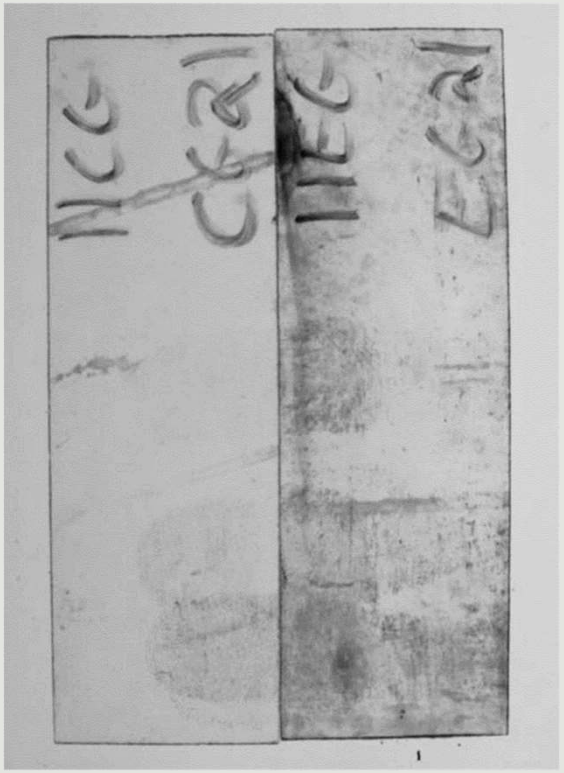
Additional work

- LSBU funded internship (Afraaz Nazir)
- Extended study to two additional corrosive substances
- 4M hydrochloric acid, ammonia
- Also looked at extended periods between deposition and treatment

4M HCl on PET

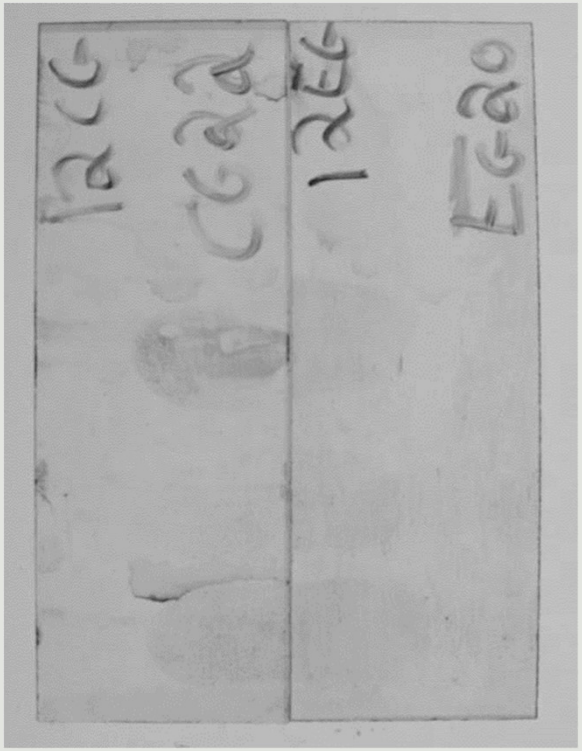


4M HCl on glass

Additional work

- No obvious effect of extending time between deposition and exposure
- Hydrochloric acid gave similar results to sulphuric acid
- Ammonia more detrimental

4M Ammonia on PET



4M Ammonia on glass

Conclusions

- Fingermarks can be recovered after exposure to 4M acid and alkali solutions
- Alkali appears more detrimental to fingermarks than acid
- Variation in performance of visualisation processes
- Results to date from a limited dataset – further work required to develop operational guidelines

Further work

- Increase number of donors used
- Increase range of corrosive substances
- Investigate effect of time since deposition and time of exposure to liquid on effectiveness
- Establish what physical and chemical changes are occurring
- Extend to other evidence types (e.g. DNA)
- Requires funding…….

Acknowledgements

- Dstl (Sandridge) for access to the VMD machine
- Rory Downham (formerly Home Office CAST) for initial work on experimental planning
- LSBU School of Applied Sciences for seedcorn funding facilitating all studies
- Chris Rawlinson (Lancashire Constabulary) for insights into exhibits received from corrosive substance attacks

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