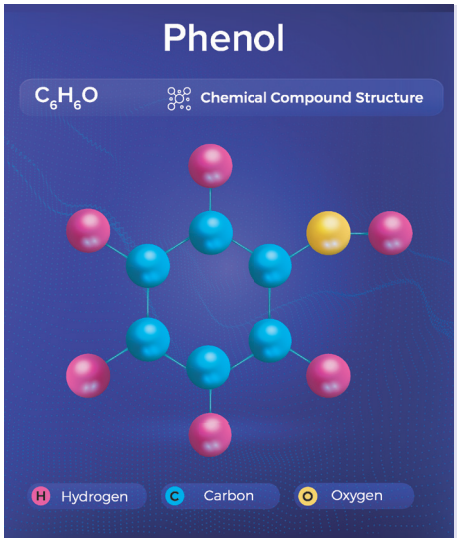

Phenol: past, present and future

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We all know what Phenol is, don't we? We're podiatrists. We regularly reach for that brown, glass bottle, or the EZ swabs, when we have a problematic ingrown toenail that needs more than just conservative treatment. But what exactly IS Phenol? Perhaps growing up, in many households, there would have been that familiar smell of carbolic soap, in the form of Lifebuoy ® or Wright's coal tar soap®. In this article, I would like to have a condensed look at what, chemically, phenol is, a brief history, past and present, and its future use within podiatry; plus, a look at some potential alternatives' worth closer investigation.

Some interesting chemical information

Phenol is a group of organic compounds, and the whole aromatic ring is bonded to an alcohol group. Because of the alcohol, it can form a strong bond with other molecules. This bond also contributes to phenol's affinity towards polar substances. It is a colourless liquid and has a high boiling point because of the strong hydrogen bonds. **Aromatic compounds** are compounds that form a cyclic ring containing double and single bonds (Huckel, 1931). In phenol, this aromatic compound is known as **benzene** (discovered by Faraday 1825, named by Mitscherlich 1833 and structure discovered by Kekule, 1865. **Fig 1**

Fig 1

Phenol is a protoplasmic poison that can result in multisystem organ failure (Downs and Wills, 2021), which makes it even more incredible that many of the proteins in our body contain phenol in their chemical structures. Serotonin (a neurotransmitter in the brain) and epinephrine both contain phenols in the naturally occurring tyrosine (polyphenol), an amino acid found in most proteins (Feduraev, 2020). Plant based compounds containing phenol are known to be antioxidants, the highest amounts being found in cranberries and red grapes (Ulaszewska et al. 2020).

Where it began

The original name is a direct derivative from the German term 'Karbolsaure', meaning coal-oil acid, given its name by Friedlieg Ferdinand Runge, a German chemist who extracted the substance from coal tar in 1834. The antiseptic qualities of Phenol were discovered early, and Joseph Lister employed it in his pioneering antiseptic surgery, though irritant qualities meant it was phased out. Lister became fascinated with the use of Phenol, which enabled his innovative sterile surgery in 1875, whilst he was working at the Glasgow Infirmary. He began to wash his hands prior to surgery and use phenol to clean wounds and sterilise instruments. This reduced the number of patients dying from post operative infections from 50% to 15%. This protocol had been suggested by Ignaz Semmelweis, a Hungarian physician. Ironically, Semmelweis died from an infected wound to his finger in 1865 that he had received during a gynaecological operation. However, the Semmelweis (1861) doctrine transformed the future of surgery.

Phenol did keep its antiseptic cleaning role as an ingredient in carbolic soap. This is still produced today but, like Coca Cola dropped the use of cocaine, the coal tar was dropped from the soap. The new soaps use Tea Tree oil to provide a mild antiseptic effect.

Unfortunately, a harrowing part of phenol's history also includes the mass extermination of concentration camp victims at the hands of Nazi guards, with a fatal injection of phenol to the heart. This was commonly used in the early phases of the camp, and thought to have been injected this way for greater efficiency (Hawinger, 2019).

Until the twentieth century, phenol continued to be extracted from coal tar but, in the early 1900s, it began to be produced from Benzene (Tosi et al.2006). Today, almost all phenol takes a different, cheaper route via Cumene. From the early days of plastic, phenol was a key ingredient, combined with formaldehyde and sawdust, to make the phenol – formaldehyde resin that is known as Bakelite.

Phenol's role specifically in podiatry began with Otto Bell (1912-1985), a Californian chiropodist who discussed its use in nail surgery (1945). His research was innovative and discussed the use of pure phenol, applied following surgery to 'remove the nail edge' and swabbing with phenol for 30 seconds; the wound was then irrigated with alcohol. Gottlieb (1953) and Nyman (1956) both reported similar mixed results. In 1962, Suppan and Ritchlin described applying phenol for 2 minutes, followed by a 3-minute application of alcohol. The use of alcohol as a lavage was disputed in 1965 (Cooper), who found that the use of alcohol was painful and could also delay healing. This was supported by Szelinsky (2021) who found that flushing the wound with alcohol delayed healing and caused increased pain.

Phenol Today

As mentioned previously, since the 1940s, the treatment of cumene with oxygen through a radical pathway, is now responsible for most industrial phenol production; this process also produces acetone. Phenols are still widely used as antiseptics and disinfectants, and are also used, in a safer form (4-hexylresorcinol!) as the active ingredient in some mouthwashes and throat lozenges. The production and consumption of bottled water has exploded during the 21st century. Bisphenol A (BPA) was first synthesised by Thomas Zincke in 1905, which led to polycarbonate plastics becoming a commonly used commercial product in the 1950's. In recent times, we have globally become much more aware how damaging the use of plastics containing BPA are, both to the environment and human health. BPA has the potential to leach into the water, which is then consumed. When BPA is present in the human body, it mimics the hormone oestrogen and can bind to oestrogen receptors, triggering hormone concentration, enzyme function and protein synthesis (Sun, 2021).

Phenol certainly has a dark side. But we have also looked at the many and varied positive uses for phenol. In our daily lives as podiatrists, and with mindful handling and storage, the results for our patients, and for patients over the past 70+ years, have, overall, been a success story.

The impact of COVID-19

The COVID-19 pandemic has been a health crisis of a magnitude with no parallel in modern times. This article will not attempt to discuss the incalculable health and human toll. The pandemic has also, however, left an indelible mark on the global economy. The production of phenol and acetone began to slip in 2019, due to a slowing economy and a poorly performing car industry. Acetone demand from 2020 has been driven by the growing need for isopropranol (IPA), which moved into acute shortage due to its use in hand sanitisers. This resulted in an escalation of prices worldwide. Demand for phenol has now started to pick up from the end users, primarily the car industry, which should increase the operating rates. This, in conjunction with, hopefully, a falling IPA demand, should result in prices under downward pressure (Hawkins, 2020).

The future of Phenol

The use of phenol within the medical field is an incredible and truly amazing story. We now take aseptic and sterile techniques for granted but, not too long ago, even the smallest cut could be deadly if infection entered the body. Lister found a way to prevent infection in wounds during and after surgery: carbolic acid/phenol made that possible (Yanes, 2018).

The global demand for phenol is forecast to report strong growth driven by consumption in major emerging markets (Report, 2019-2025, Future of Global Phenol Market). It does seem appropriate, however, given the potential for future fluctuating markets and the potential toxicity of phenol, to look at other safe modalities for matrix destruction or excision.

Chang et al. (2020) undertook a systematic review and network meta-analysis to compare chemical matrixectomy with trichloroacetic acid, phenol and sodium hydroxide for ingrown toenails **(Table 1).**

The results showed the trichloroacetic acid (TCA) was an effective and safe cauterant for chemical matrixectomy, with the advantage of quicker healing and a less duration of post operative pain. These findings were supported by Ramesh et al. (2020) in their research on comparative efficacy. Trichloroacetic acid is also a cheap and easily available chemical.

Table 1:
Comparison of post treatment infection, pain and recurrences n=91

Variable	Categories	88% Phenol	90% Trichloro-acetic acid	P value
Pain	No pain	18	21	0.472
	Mild pain	23	19	
	Moderate pain	4	4	
	Severe pain	2	0	
Wound Infection	Yes	14	09	0.306
	No	33	35	
Wound Discharge	Yes	5	2	0.436
	No	42	42	
Recurrence	Yes	0	2	0.495
	No	47	42	

The use of phenol within podiatry is well established, and it is now the safest, simplest and most performed method used, with the lowest recurrence rate (Haneke, 2012). Elevation of the nail margin, with excision and cautery of the granulation tissue, was described by Aegineta as far back as 690AD; there continues to be many surgical variations today, including the Vandenbos technique, Noel's procedure, DuVries, Zadik, terminal Syme, plus many more. Elbendary (2020) discusses numerous surgical techniques, plus other treatments including CO2 laser, electrocautery, curettage and cryotherapy, with their potential outcomes.

I believe, as a podiatrist, there is never a one-size-fits-all and being able to assess our patients holistically to offer the most appropriate treatment, is exciting and positive. Learning the skills, through practical training, peer discussion and mentoring, underpins the confidence and competence necessary to enable us to treat safely and successfully, which is, of course, paramount.

See overleaf for References

A national patient safety alert has been issued for the use of Liquefied Phenol 80%.
To read the full alert visit our website - www.iocp.org.uk/category/general-news

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Fig. 1 Parody of Kelule's single snake 1886. Berichte Der Durstigen Chemischen Gesellschaft (Journal of the Thirsty Chemical Society).

Table 2. Chang, HC et al. 2020. Comparison of chemical matrixectomy with trichloroacetic acid, phenol or sodium hydroxide for ingrown toenails: a systematic review and network meta-analysis. Acta Derm Venereal