Supporting Information

THERMOLON™
HEALTHY NON-STICK COATINGS

July 2007

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EXECUTIVE SUMMARY

Until today, all non-stick cookware coatings were based on PTFE, which as this document points out, has several disadvantages in practical household use as well as for health, safety and the environment. For example, toxic and carcinogenic chemicals are released when PTFE is heated above 500°F (260°C).

Moreover, PTFE non-stick coatings are manufactured with the use of a processing aid called PFOA, which is classified by the US Environmental Protection Agency (EPA) as a persistent chemical and a "potential" carcinogen. The chemical appears to be present in the blood of a large proportion of the American population and is slow to be cleared from the body.

Following various animal and human studies, the traditional non-stick coating manufacturers are working to phase out PFOA by the year 2015.

The good news is that a new, completely safe non-stick surface has been discovered that does not use any PTFE or PFOA in its manufacture. Naturally, the benefits of non-stick cooking - ease of cleaning and little or no oil/fat needed - are not lost.

Supplied by Thermolon Ltd, the coating is a polymer hybrid nanocomposite that has been tested as being 100% in accordance with food contact regulations set by the U.S. Federal Dugs Administration (FDA) FDA CFR21 § 175.300 and the German LFGB §30 and §31 (previously known as LMBG §30 and §31).

Cookware coated with THERMOLON™ is available now.

1. PATENTED NON-STICK TECHNOLOGY

1.1 What is Thermolon™?

THERMOLON™ is a patented* coating that is:

- Hybrid polymer nano-composite technology
  - PTFE-free
    - Zero PFOA (APFO)
      - Highly temperature resistant - to 450°C (842°F)
        - ***Healthy for your cooking!***

In contrast, no conventional PTFE coating can claim any of the above features.

1.2 Thermolon™ Functionality

In addition, THERMOLON™ is:

- Food-contact compliant (FDA, 21 CFR §175.300; LFGB §30 and §31)
  - Exceptionally ***non-stick***
    - Extremely durable
      - Scratch resistant
        - Corrosion resistant and dishwasher-safe

With a significantly lower curing temperature, application of THERMOLON™ saves energy, thereby substantially reducing CO_2 emissions.

Further information on energy-savings is provided in Section 7.

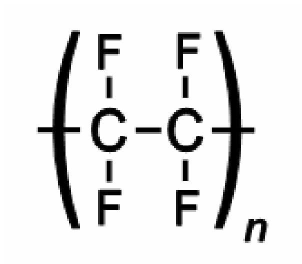
2. PTFE-FREE

THERMOLON™ contains no PTFE whatsoever. Nevertheless it has remarkable food release properties.

To understand why zero PTFE is such a significant health and environmental benefit, we must first examine the drawbacks of PTFE.

2.1 PTFE

PFTE (Polytetrafluoroethylene) is a fluoro-polymer that is widely used in non-stick coatings for cookware due to its extremely low frictional properties and general inertness.



Repeat unit structure of PTFE

Unusually for a polymer, PTFE has a relatively high melting point (or gel point) around 335 °C (**635** °F) [1].

However, according to manufacturers of PTFE-based non-stick coatings[2],

- *Cookware with PTFE non-stick coatings has a recommended* *<u>maximum use temperature</u>* *of 260 °C (* ***500°F*** *)**

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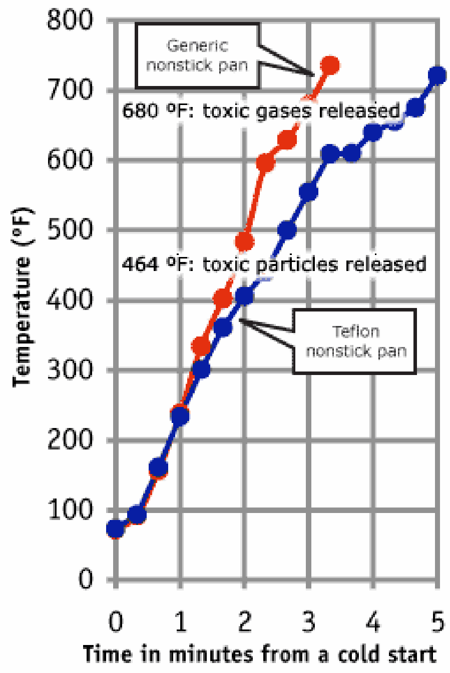
*Note: PTFE does not really have a sharp melting point in the normal definition. Instead it gradually softens but it is not molten. At higher temperatures it decomposes, hence the maximum recommended use temperature for food contact applications.

Although PTFE manufacturers claim that: *typical cooking temperatures are much lower*, tests show that a frying pan can easily reach a temperature of 391°C (**736°F**) or higher in just a few minutes on a conventional stove[3,4] ▶

Figure 1: Teflon pans on stovetop burners easily reach temperatures that produce toxic particles and gases



Source: University Food Safety scientist and Environmental Working Group. Tests conducted on May 12 and 13, 2003.

- At a temperature of 240°C (**464°F**), release of PTFE particles has been observed[5,6]
- By 290°C (**554°F**) emission of ultra-fine oxidized particles can occur[7]
- At 360°C (**680°F**) a cocktail of toxic and carcinogenic gases is given off[5]
- Between 360-600°C (**680-1112°F**) there is release of TFE (tetrafluoroethylene), a reasonably anticipated human carcinogen[8,9]
- Above 360-650°C (**680°F**) there is emission of HFP (hexafluoropropene)[8,9]
- Above 440°C (**824°F**) COF_2 (carbonyl fluoride) is released - a fluorinated derivative of phosgene, a chemical warfare agent[7,9]
- Above 440°C (**824°F**), PFiB (perfluoroisobutene, a warfare agent 10 times more toxic than phosgene) is detected[7]
- Above 650°C (**1202°F**) decomposition releases carbon tetrafluoroide (CF_4)[10]

All the above landmark temperatures are readily attainable within just 5 minutes when non-stick cookware is dry heated on a conventional stove.

According to *PubMed* (a service of the US National library of medicine[11]:

> *any industrial or household activity in which PTFE is heated above 350-400 degrees C puts nearby workers or residents at risk of illness and is to be avoided without strict industrial hygiene controls*.

2.2 PFOA

PTFE dispersions, which are used in non-stick coatings for cookware, are manufactured by a process that involves emulsion polymerization of TFE (tetrafluoroethylene) in water. During this process an emulsification agent, commonly known as **PFOA** (perfluorooctanoic acid) or “C8”, is used.

As the U.S. Environmental Protection Agency notes[12]:

- *PFOA is a synthetic (man-made) chemical that does not occur naturally in the environment*

Although major manufacturers of non-stick paints claim that PFOA is completely destroyed during the process of coating and curing, they admit that under extreme conditions traces of PFOA can be detected[2]:

- *However, according to a recently published study conducted by researchers at the US Food & Drug Administration (FDA),* ***PFOA was detected*** *in minute quantities in cookware using extreme and abusive test methods – methods that do not reflect what happens when consumers use cookware. The quantities of PFOA detected through these extreme measures were too small to measure migration of the PFOA out of the cookware. Published, peer-reviewed research clearly shows that cookware is safe for consumer use.*

Although the level of PFOA in PTFE non-stick cookware is below the limits of detection (in migration tests), PFOA is very persistent in the environment and may accumulate and last for several years in the human body[13,14].

In fact, studies show that traces of PFOA can now be detected in the bloodstream of most of the American population and can be found in the wider environment[13-15].

Moreover, PFOA, accumulates in the body and is reported to pass through the placenta into the unborn child in pregnant women[15].

- As recently as February 2006, EPA's Science Advisory Board voted to approve a recommendation that PFOA should be considered a likely carcinogen[16-18]

At the moment, scientific studies are being carried out to determine how PFOA enters the body and the extent of its dangers to our health.

In the meantime, manufacturers of PFTE non-stick coatings are aiming to phase out the use of PFOA by the year 2015 under a voluntary stewardship program initiated by the USA's Environmental Protection Agency (EPA).

At Thermolon Ltd, we say there is no need to wait another 8 years!

Because THERMOLON™ is certified as being completely PTFE-free, there is no PFOA or substance similar to PFOA that is used in its manufacture (for the certification, please turn to **Appendix A2**).

3. THERMOLON™ PERFORMANCE

THERMOLON™ is a revolutionary non-stick coating without any PTFE. It therefore has strengths where conventional non-stick coatings only have weaknesses.

Below we make comparison between THERMOLON™ and a conventional 3-layer non-stick coating on aluminium cookware.

No.	Property	Thermolon	PTFE Non-stick (3-layer)
1	PTFE Content	Zero	to ~30%
2	Temperature resistance	+++++	++ (to 260 ℃ max)
3	Temperature Stress (500℃; 2 hrs)	+++++ (no defects)	- - - - -
4	Flame test (gas torch, blue flame)	+++++ (intact at 600℃)	- - - - - (decomposes)
5	Particles at 260-290℃	+++++ (none)	- - - - - detected[5,7]
6	Temp. shock (300℃, 1 h, then quench in cold water; x 10)	+++++ (no defects)	- - - - (cracked, aged, peeled)
7	Gloss (60°)	+++++ (gloss to 85)	+ (gloss 20-30)
8	Corrosion resistance (boiling 10% NaCl; 24 h)	+++++ (no defects)	++ (blisters)
9	Salt spray test (1,000 h)	+++++ (no defects)	- - - - - (cracked, peeled)
10	Boiling resistance (98℃; 2 h)	+++++ (no defect)	+++ (gloss diminished)
11	Acid resistance (15%H_2SO_4, 24 h)	+++++ (no defects)	+/-
12	Acid resistance (40%HNO_3, 24 h)	+++++ (no defect)	+
13	Hardness (Mitsubishi pencil)	+++++ (9 H)	+/- (1 to 3 H)
14	Release properties (fried egg test)	+++++(+)	+++++
15	Abrasion test, 4.5 kg weight	+++++	+++
16	Adhesion (cross hatch, boil for 15 min, then tape pull)	+++++	+++++

Additional test data are appended (**Appendix A3**).

4. THERMOLON™ TEST STANDARD

THERMOLON™ is totally different to traditional non-stick coatings. Apart from being completely free of PTFE and PFOA, its properties provide performance benefits where traditional coatings tend only to have weaknesses as may be seen from the table in Section 3.

Because traditional coatings have such weaknesses, non-stick coating test methods tend to have been prescribed by the coating industry itself with the aim of highlighting certain areas of performance whilst overlooking areas in which these coatings are know to be weak.

At Thermolon Ltd, we have raised the bar by setting new test standards, which we consider our consumers should insist upon.

Our test criteria are summarized below.

1.	**Release properties (fried egg)**
1.1	Wash the cookware interior with mild detergent (e.g. dishwasher detergent), dry and place the product on an electrical hob or gas burner.
1.2	Turn on the heat, and raise the temperature of the cooking surface to ~150℃.
1.3	Crack egg, pour contents into center of cookware item, and cook until egg white turns milky in appearance; then turn egg over with wooden/plastic spatula.
1.4	Egg must be easy to remove with no visible sticking on the coating's surface.
1.5	Wipe interior of pan with clean cloth and the repeat process until 5 eggs have been fried. Grade the release performance on a scale 1-5, where 5 indicates perfect release on each of the 5 cycles.

2.	**Test according to “No migration principal”**
2.1	A statement shall be provided by the manufacturer of the interior coating in confirmation that nothing from the coating shall impart flavour, colour, odour, toxicity or any other undesirable characteristics when in contact with food.
2.2	An independent test certificate shall be provided confirming that the coating itself is suitable for use in regular food contact according to International Food Contact Regulations.

3.	**PTFE (or other fluoro-polymer) content of coatings**
3.1	A statement (or other documentary proof) shall be provided from the supplier(s) of the interior coating and exterior coating to confirm the PTFE (or other fluoropolymer) content if any in each layer of the interior coating.
3.2	If there is any PTFE (or other fluoro-polymer) contained in the interior or exterior coating then the supplier(s) shall distinguish between the Dispersion form or any other form of the content (e.g. PTFE powder form).

4.	**PFOA content of cookware coating**
4.1	A certificate from an independent test centre shall be provided as validation of whether there is any detectable amount of PFOA in the wet sample of non-stick paint (i.e. before its application to the interior of cookware).
4.1	A certificate from an independent test centre shall be provided as confirmation that migration of PFOA (if any) from the coated cookware into food simulants including water, acetic acid and olive oil are below the limits of detection or at least below the migration limits stated in the “Recommendation LI” of the German BGVV (former Bundesgesundheitsamt).

5.	**Heat transfer**
5.1	Place 100 g water inside cookware. Place on gas hob and turn to maximum power. Note the time that is taken to boil all the water dry.
5.2	Make comparison with boil dry time by using the same cookware item (of same substrate and same substrate weight) but coated with energy-saving coatings such as “Whitford” Halo or “DuPont Radiance. Between test items the gas supply should not be turned off or adjusted but should be maintained on maximum power.
5.3	Test report should note the weight of the substrate (without handle), substrate gauge, type of coating; time to boil dry.

6.	**Boil dry test**
6.1	Fill the cookware with 0.25 L of cold distilled water. Heat on a 3000 W electric stove set to maximum power until all the water has evaporated. Continue heating at maximum power for a further 10 min. Temperature of the inside is measured and noted down after 0, 4, 7 and 10 min. After 10 min remove sample from the heater and measure the temperature of the base.
6.2	Observe any changes in the exterior coating and record final condition.
6.3	Observe any changes in the interior coating and record final condition.

7.	**Temperature stress resistance**
7.1	Heat to 300℃ and maintain temperature for 1 ho ur; record condition of both interior and exterior coating; if no defect then continue to next stage -
7.2	Heat to 350℃ and maintain temperature for 2 ho urs; record condition of both interior and exterior coating; if no defect then continue to next stage
7.3	Heat to 400℃ and maintain temperature for 2 ho urs; record condition of both interior and exterior coating
7.4	At each of the above stages, observe whether there is any gaseous or particulate material released from the interior or exterior coating

8.	**Temperature shock**
8.1	Heat to 300℃, maintain interior temperature for 1 hour, then quench in tap water at ambient temperature; repeat for 10 cycles
8.2	After each cycle note whether there is any change in appearance or damage to either the interior or exterior coating

9.	**Abrasion resistance**
11.1	Carry out abrasion test according to the BS standard with Scotch-brite pad and with applied force of 4.5 kg to the abrader.
11.2	Interior coating should withstand a minimum of 4,000 cycles under 4.5 kg force without being abraded down to the metal

10.	**Hardness**
12.1	Determine hardness of interior and exterior coating on scale of pencil hardness with reference to a standard Mitsubishi pencil set
12.2	Minimum pass requirement is 3H

5. THERMOLON™ - HEALTHY COOKING

5.1 PFOA Analysis

THERMOLON™ is healthy for your cooking because it contains no PTFE and, therefore, does not contain any PFOA (as certified in **Appendix A2**).

5.2 Metal Analysis

THERMOLON™ contains no detectable levels of the following metals:

- Lead (Pb)
- Cadmium (Cd)
- Arsenic (As)
- Antinomy (Sb)
- Chromium (Cd)

A comprehensive metal analysis is appended (**Appendices A4.1**).

5.3 Safety Analysis

A comprehensive analysis showing zero extractives from the coating (i.e. compliance with the Zero Migration Principle) is appended (**Appendix 4.2**).

The food contact surface was exposed to the following media at a temperature of 68℉ (20℃) for a period of 24 hours in each case:

i) 5% H_2SO_4 (sulfuric acid)

ii) 5% NaOH (sodium hydroxide)

iii) Xylene

iv) MIBE (methyl iso-butyl ether)

v) MEK (methyl ethyl ketone)

No migration of substances from the coating to the above media was detected, thus fulfilling the No Migration Principle.

5.4 International Food Contact Regulation Compliance

Certificates of analysis from SGS (Hong Kong) are appended (**Appendix 4.3**).

The test report from SGS (Hong Kong) confirms that Thermolon™ complies with:

(i) FDA, 21 CFR §175.300;

(ii) LFGB §30 and §31 (previously known as LMBG §30 and §31).

6. GASES AND EMISSIONS

The production and application of THERMOLON™ are relatively benign processes.

In contrast, manufacture of non-stick PTFE coatings and their application are hazardous and have a higher negative impact on health and the environment:

- PTFE manufacture - highly ***energy-consuming*** processes
- PTFE Raw Materials - ***toxic / carcinogenic***
- PTFE processes - ***environmentally unfriendly***, contributing to *Global Warming*

6.1 PTFE Non-stick Coatings

Processes of PTFE coating manufacture and application are outlined in the following sections. Additional information may be found in **Appendix A5**.

6.1.1 Steps in Manufacture of PTFE

The following five basic steps summarize the processes used in the manufacture of PTFE (otherwise known as Polytetrafluoroethylene or Polytetrafluoroethene).

Hydrofluoric acid (HF) is one of the basic materials used to manufacture PTFE. It is produced from the reaction of sulfuric acid with calcium fluoride:

I.	CaF_2	+	H_2SO_4	→	**2 HF**
	(Calcium fluoride, or fluorspar)		(Sulfuric acid)		Hydrofluoric acid)

!!!HF is one of the strongest and most corrosive acids known to man!!!

The next step is a ***high temperature*** reaction – i.e. has a high energy demand.

II. $CHCl_3$ + 2 HF → $CHClF_2$ + 2 HCl ***(600 °C)***
(Chloroform) (Chlorodifluoromethane)

Chloroform (otherwise known as Trichloromethane or TCM) is a ***known carcinogen.***

Chlorodifluoromethane is also known as Freon, Arcton-22 or HCFC-22, an ***ozone-depleting refrigerant gas.***

III. Chlorodifluoromethane ($CHClF_2$) is then heated in super-heated steam at a pressure of **6 bar** and temperature of **900 °C,** which results in production of difluorocarbene ($:CF_2$). Again, this is a highly ***energy-intensive*** process.

IV. $:CF_2$ then dimerizes to form tetrafluoroethylene (**TFE**):

2 ($:CF_2$) → $CF_2{=}CF_2$ + higher polymers + perfluoroisobutylene
(**TFE**) (**PFiB**)

TFE is hazardous material and a ***suspected carcinogen***
PFiB is ***ten times more toxic than phosgene*** (a chemical weapon)

V. Emulsion polymerization of TFE in water containing an initiator and emulsification agent known as **PFOA**.

PFOA (Perfluorooctanoic acid) is highly persistent in the environment, can be found in the blood of most Americans (including unborn fetuses) and is considered by the scientific advisory board to the US EPA as a likely carcinogen[15,16]. Environmental and health hazards of PFOA are discussed in more detail in Section 2.2.

Although most of the PFOA is mostly removed from PTFE dispersions following manufacture, small amounts (in range 10-50 parts per million remain that can be detected in non-stick PFTE paints that are handled by the workers on cookware coating lines al around the world. The PFOA content of PTFE paint is quantified in the attached report (**Appendix A6**).

6.1.2 Intermediates and Byproducts of PTFE Manufacture

Manufacture of PTFE, as we have seen, produces intermediates and byproducts that include:

- corrosive acids
- highly toxic chemicals
- green house gases
- carcinogens

There is documented evidence that workers exposed to fumes from PFTE manufacturing can suffer an illness called polymer fume fever.

Perfluoroisobutene (PFiB) is a fluoro-olefin produced by thermal decomposition of PTFE. Overheating of PTFE generates fumes of highly toxic PFiB, which is approximately **ten times as toxic as phosgene.**

Evidence of the highly toxic nature of PFiB is presented in **Appendix A7.**

6.1.3 Application of PTFE Coatings

The application of a three coat PTFE non-stick coating requires three separate spraying stages, as may be see from Figure 2, for:

- Primer
- Mid-coat
- Top coat

Four different ovens are required for the process, each of which demands energy:

- Pre-heating oven before primer
- Primer Flash Off (drying) oven at 120-150 °C
- Flash off zone after Mid/Top coat
- Curing oven ***~430 °C – the most energy intensive stage***

After curing the interior PTFE-based coating the exterior decorative coating is then applied in a second separate coating operation. The exterior coating is then cured.

This means that when using PTFE coatings, it is common to have two passes through the curing oven (i.e. one pass for the interior coating and then a second pass through another oven for curing the exterior paint).

- ➢ With Thermolon™ the interior and exterior coatings are cured together (i.e. jus one pass through the oven)

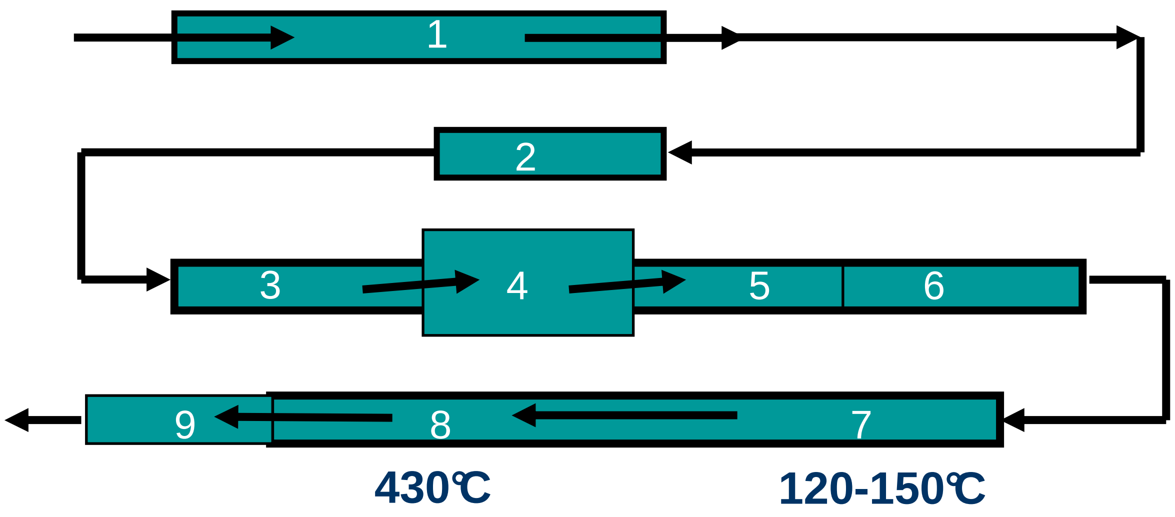
The process of applying PTFE non-stick coatings

- ➢ exposes workers to the dangers of spraying PTFE paints containing PFOA in three different spray booths

- ➢ Is highly ***ENERGY INTENSIVE***

Fig. 2: APPLICATION OF PTFE

SPRAY LINE

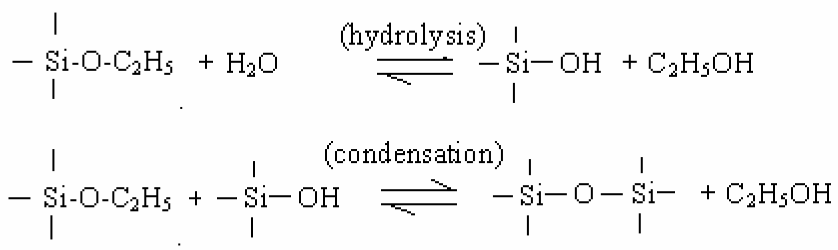


1. Pre-treatment
2. Sand blasting
3. Primer
4. Primer Flash Off
5. Mid-coat
6. Top-coat
7. Flash-Off Zone
8. Curing
9. Cooling

6.2 Thermolon™ Non-stick Coatings

6.2.1 Steps in Manufacture of Thermolon™

Thermolon™ is based on a Sol-Gel process as summarized by the following simplified reaction equation:



Further condensation reaction leads to the growth of the polymer ceramic nano composite structure.

The formation of the macromolecules is carried out at moderate temperatures without the formation of hazardous by-products or toxic waste.

6.2.2 Application of Thermolon™

- Restricted Area: more information can be obtained on request. Thermolon Ltd can be contacted at info@thermolon.com.

7. ENERGY SAVING IN APPLICATION

7.1 Energy Required for Curing a Non-stick Coating

In comparison with Thermolon™, traditional non-stick, PTFE coatings are doubly inefficient in their energy demand in the curing oven.

As may be seen from their curing oven temperature profiles:

- PTFE requires a peak curing temperature that is ~40% higher than for Thermolon™

- PTFE requires a 50% longer time in the curing oven

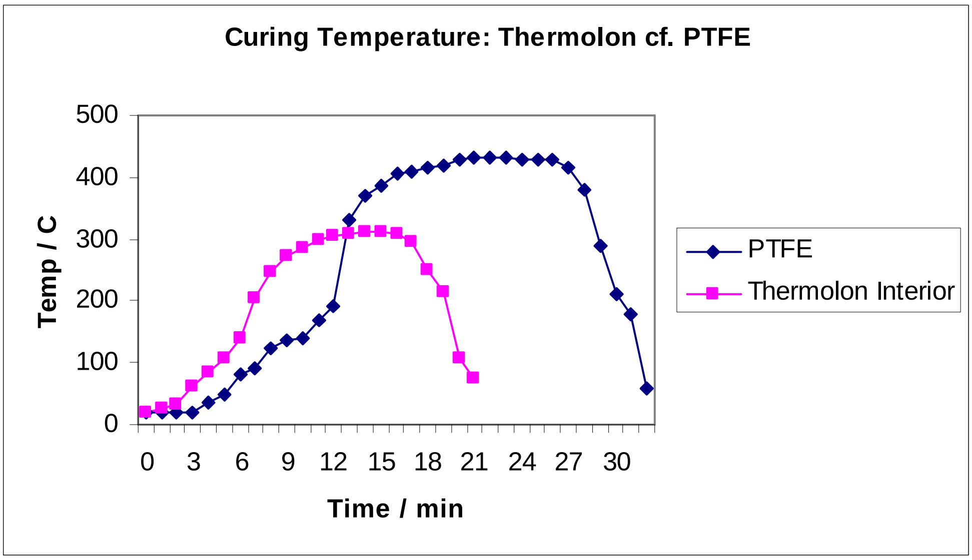


Fig 3: Curing Oven Profile for (i) 3-layer PTFE and (ii) Thermolon™.
Curing oven 25 m long with three heating zones of length 7.0 m, 6.5 m and 6.5 m.
Oven line speed: 0.8 m/min for PTFE; 1.2 m/min for Thermolon™.
Data courtesy of Anotech International (HK) Ltd (Chief R&D, Kurt Blondeel)

For the PTFE non-stick coating, the longer time spent at higher temperatures translates into a significantly higher energy requirement.

The following chart shows the increase in the amount of fuel oil (Diesel) consumption with increases in peak oven temperature.

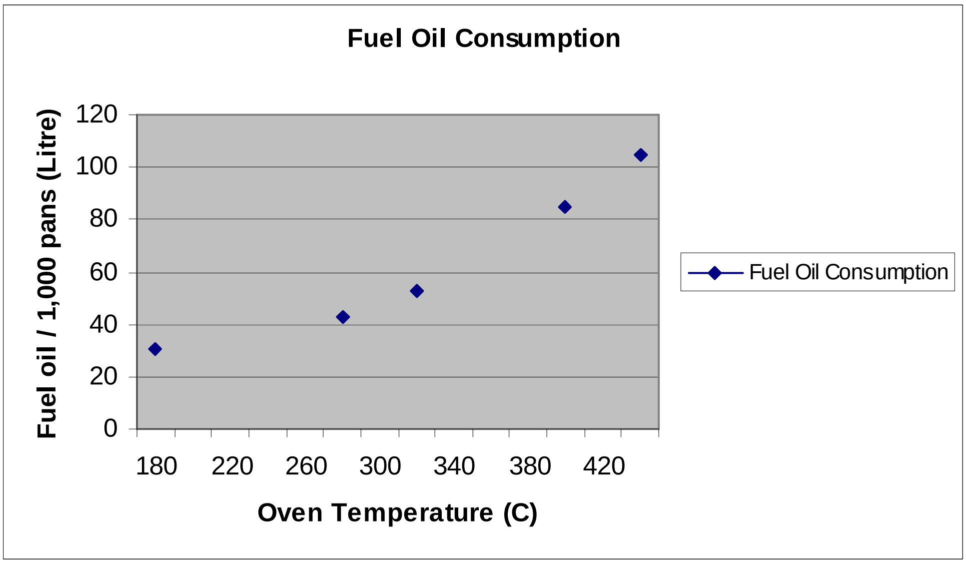


Fig. 4: Oil consumption data at different peak curing temperatures.
Curing oven 25 m long with three heating zones of length 7.0 m, 6.5 m and 6.5 m.
28 cm diameter aluminium frying pans each of mass 1.019 kg.
Data courtesy of Anotech International (Chief R&D, Kurt Blondeel)

For the conventional coating, where the maximum set oven temperature is 438℃ and the oven line speed is only 0.8 m/minute, the amount of fuel oil consumed in curing 1,000 frying pans is approximately **105 Litre** (or 1,218 kWhour)*.

*Note: Combustion of 1 Litre of Diesel oil generates 11.6 kWhour
DETR/ETSU (UK), 2 November 2000;
http://www.defra.gov.uk/Environment/ccl/pdf/na(00)59.pdf

By reducing the maximum set oven temperature to 320℃ and increasing the speed through the oven to 1.2 m/minute as required by Thermolon™, the fuel oil consumption per 1,000 pans reduces to only **53 Litre (or 614.8 kWhour)**.

- *PTFE non-stick coatings require approximately double the amount of energy for curing*

This estimate of the energy-savings with Thermolon™ is considered to be conservative because it does not include the energy that is saved by curing the interior and exterior coating in one single pass through the curing oven.

7.2 Reduction in CO_2 Emissions

Halving the curing energy per pan by using Thermolon™ non-stick coatings reduces energy-demand related Carbon Dioxide (CO_2) emissions.

Burning of 105 Litre of fuel oil for curing 1,000 pans coated with 3-layer PTFE emits around ***1,218 kg of CO_2***. (Additional energy is then used for application and curing of the exterior decorative coating, which generates additional CO_2 emissions).

In contrast, only ***615 kg of CO_2*** are released when 1,000 pans are coated with Thermolon™ (interior and exterior) are cured.

- ***For a single cookware program of 2 Million pans, the anticipated reduction in CO_2 emissions would be in excess of 1,200 tons.***

TERMINOLOGY

Abrasion resistance is a measure of the ability of a coating to withstand abrasion through contact with a rough material. It is often quantified in an Abrasion Test whereby a Scotch Brite pad under a specified force is reciprocated for a given number of cycles across the coating's surface and the decrease in coating thickness is recorded.

Adhesion of a coating is its ability to adhere to the surface of a substrate without being delaminated by mechanical force or thermal cycling.

Acid and alkali resistance is the ability of a coating to protect the substrate (metal underneath) from attack by acid or alkaline media. This is often quantified by the number of hours that a coated substrate can withstand being immersed in an acid or alkaline solution of stated concentration and temperature without the substrate being impaired.

Carbon tetrafluoroide (CF_4) is a gas that is released by decomposition of PTFE above 1,202℉ (650℃). Inhalation at low concentrat ions may cause narcotic effects or other symptoms including dizziness, headache, nausea and loss of co-ordination.

Carbonyl fluoride (COF_2) is a fluorinated relative of the chemical warfare agent known as phosgene. It is a gas released when PTFE is heated above 824°F (440℃).

Carcinogens are substances that cause cancer in humans or other animals.

Chlorodifluoromethane *(*$CHClF_2$) - raw material used in the production of PTFE which is ozone-depleting.

CO_2 (carbon dioxide) - a greenhouse gas that is produced by the generation of electricity from burning fossil fuels, which is a major contributor to climate change.

Corrosion resistance is the ability of a coating to protect the substrate (metal underneath) from corrosion. Resistance is often quantified by the number of hours that a coated substrate can be boiled in a 10% aqueous salt (NaCl) solution without the substrate being impaired.

Curing is the process of drying the coating during which the properties of the coated surface are developed. For conventional PTFE non-stick coatings, this process is carried out in a curing oven in which the peak oven air temperature may reach above 824℉ (440℃). This process is highly energy-inten sive. Therefore, the lower the curing temperature that can be used the greater the energy that can be saved – as with Thermolon™.

Dispersion is the term used to describe a liquid in which another liquid or solid material is finely suspended. For example, PTFE is a solid at room temperature, but the form in which it is used for manufacture of non-stick coatings is normally an aqueous dispersion. Owing to the fineness of the PTFE particles, the PTFE dispersion has a milky appearance.

Flash-off is an intermediate drying of the primer before mid- or top-coat can be applied.

Fluoropolymers are class of polymers where the molecular formula of the repeat unit in the polymer contains atoms of fluorine (F). The substitution of fluorine in the molecular structure makes the polymer relatively inert and heat resistant. One of the most important examples of a fluoropolymer is PTFE.

Hardness of a coating is a measure of its ability to resist damage by another material of a given hardness. A common way of quantifying hardness is on a scale of pencil hardness.

HPF (hexafluoropropene, C_3F_6) is a gas that is released from PTFE when it is heated above 680℉ (360℃). It is classed as harmful by in halation and irritating to respiratory system.

International Food Contact Regulations - an article used in food contact must comply with the “No Migration Principle”. This means that nothing from the articles can impart flavour, color, odor, toxicity or any other undesirable characteristic to food.

Mid-coat is a layer of a coating that is applied after the primer but before the top-coat. It is often used to impart strength (or reinforcement) to the coating and to form an interface between primer and top coat.

Multi-layer coating – conventional PTFE non-stick coatings require two or more layers in order to make them more durable. The disadvantage is that the more layers that are used, the more spraying operations are involved. Each spraying operation involves losses of coating into the atmosphere, which makes the coating process less efficient and increases emissions of pollutants.

Nano-technology relates to use of materials with dimensions on a nanometer (nm) scale – that is just one millionth of a millimeter (mm).

Non-stick coatings for cookware or bakeware are a material that is applied to the substrate to prevent the sticking of food during cooking and to render them easy to clean after cooking. Non-stick coatings commonly contain PTFE or silicone oil to aid the release properties of the surface.

PFiB (perfluoroisobutene) is a gas released from PTFE when heated above 824°F (440°C). It is ten times as toxic as phosgene, which is a chemical warfare agent. Inhalation of this gas can cause pulmonary edema and can lead to death.

PFOA (Perfluorooctanoic acid), sometimes referred to as "C8", is used as a processing aid in the manufacture of PTFE dispersions and other fluoropolymers. It is very persistent in the environment and is very slow to be eliminated from the human body. Currently there is concern because PFOA can now be detected in the blood stream of most Americans, but the mechanism by which it enters the body is not understood. There is growing evidence that PFOA should be considered as a likely carcinogen.

Polymers are natural or synthetic long chain molecules composed of a simpler molecule (or repeat subunit) linked together to form a material which, depending on the type of subunit and length of the chain, can be designed with specific mechanical and physical properties.

Primer (or base coat) - the first layer of coating that is applied to the substrate.

PTFE (Polytetrafluoroethylene) is a fluoropolymer comprising repeat units of a simpler molecule called tetrafluoroethylene forming the structure $-[CF_2-CF_2]_n-$ (n is the number of times that the unit is repeated in the chain). PTFE is widely used to impart non-stick properties to cookware coatings because of its low coefficient of friction. Its temperature stability is up to 260°C when used for food-contact applications.

Release properties of a coating refer to the degree to which food does not stick to the surface during or after cooking. It is often assessed by tests such as frying eggs or caramelizing sugar inside coated cookware under a standard set of conditions.

Scratch resistance is the ability of a coating to withstand scratch marking when sharp implements are applied with motion and force to the surface. A common test for scratch resistance is the Tiger Paw test. This is a hand-operated or automated device incorporating three ballpoint refills. This device is without any additional weight is placed on the surface of the cookware and is spiraled along the surface. The greater the number of "tiger paw" cycles before coating is removed down to the substrate the higher the scratch resistance.

Substrate refers to the material of the article that is to be coated.

Temperature resistance refers to the maximum temperature to which a coating may be subjected before physical or chemical changes occur, rendering the coating unfit for further use.

Thermolon™ is a non-stick hybrid polymer nano-composite coating that has very good release properties but contains absolutely zero PTFE.

TFE (tetrafluoroethylene, CF_2-CF_2) is a highly flammable, colorless gas that is insoluble in water. It is used as the basic building block of PTFE. When PTFE is heated above 680°F (360°C) TFE is released. TFE is classed as a reasonably anticipated human carcinogen.

Top-coat is the layer of a coating that is applied directly onto the primer (in a 2-coat system) or onto the mid-coat (in a three layer system).

Toxic substances are capable of causing harm or death by chemical means.

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APPENDICES

- Restricted Area: more information can be obtained on request. Thermolon Ltd can be contacted at info@thermolon.com.