Formaldehyde in Top knitted Children's Wear within Egyptian Market

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Abstract
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Formaldehyde is a reactive, strong-smelling gas at room temperature; children, especially those with diagnosed asthma, may be more likely to show impaired pulmonary function and symptoms than are adults following chronic exposure to formaldehyde. Textile materials containing treating formaldehyde resins widely used in cotton, cotton/ polyester or wrinkle-resistant linen; as well used in anti-shrink agents mainly in cellulosic fabrics. On the other hand, some other after treatment of substantive dyeing, hardening of casein fibers, as a wool protection agent, anti mould and above all as a cross linking agent in resin finishing.
The purpose of this paper is to first, focus on the toxicity literature of formaldehyde being used into garments, secondly, the reality of the presence of such a chemical into children wear within Egyptian market.
A sample of thirty knitted cotton top garments, all of which are children's wear collected randomly from the Egyptian market, has been tested using both Spot test and EN ISO 14184-1:1998 Textiles – Determination of Formaldehyde – Part 1: Free and Hydrolyzed Formaldehyde (Water Extraction Method) detecting formaldehyde presence and percentage within tested samples.
Conclusion was drawn based on resultant data, out of thirty children's cotton, cotton blended knitted dyed and printed t-shirts, all obtained <10ppm or <16ppm according to Spot Test and EN ISO 14184-1:1998, respectively, examined at both Egyptian Textile Development Centre of the Textile Consolidation Fund and Intertek consumer goods Egypt laboratory. Knitted cotton and cotton/polyester Children's top wear were detected formaldehyde free within Egyptian market.

Keyword:
Formaldehyde - knitted Children's Wear - chemical emissions - Children suffering asthma

Introduction

Formaldehyde is a colorless, reactive, strong-smelling gas at room temperature. It is one chemical in a large family of chemical compounds, CH_2O, called volatile organic compounds (VOCs). The term volatile means that the compounds vaporize or become a gas at room temperature. Formaldehyde can be manufactured as a liquid (formalin) or a solid (paraformaldehyde); it is used as an intermediate in the manufacture of melamine, polyacetal, and phenolic resins (Solman et al. 2008). Formaldehyde is an important industrial chemical used to make other chemicals and different types of products, such as: home furnishings, household cleaners, paints, textiles, landscape and yard products, medicinal and personal care products, and pesticides (CPSC 2013).

Currently, the use of seven different classes of chemicals in textile production and processing are taken into consideration, when issuing eco labels. These are Formaldehyde, Toxic pesticides, Pentachlorophenol (PCP), Heavy metal traces, Azo dyes which release carcinogenic amines, Halogen carriers and Chlorine bleaching (Basant and Rani 2013).

Formaldehyde in Textiles

Formaldehyde-containing resins have been used in clothing and other textiles since the mid-1920s primarily to impart durable press characteristics to fabrics made from natural fibers, especially plant-based fibres such as cotton (Iversen O.H. 1986). These resins may also provide other easy-care benefits, such as shrink resistance and colour fastness (Le Coz 2001). Formaldehyde may also be used in binders for prints, in various coatings such as fire retardant chemicals. By the 1950s and 1960s, the use of these resins in cotton clothing and other textiles became more prevalent to compete with the increased use of the durable press characteristics synthetic fabrics (GAO 2010). Durable press expression is used to encompass terms such as wrinkle resistant, wrinkle free, non-iron, no iron and easy care. The durable press fabric characteristic applies to

items treated to retain their shape and pressed appearance after many uses, washing and tumble drying. All-synthetic fabrics, such as 100 percent polyester, are inherently durable press and do not need to be treated by formaldehyde-containing resins.

From the above, textile materials containing treating formaldehyde resins widely used in cotton, cotton/polyester or wrinkle-resistant linen. On the other hand, some other after treatment of substantive dyeing, hardening of casein fibres, as a wool protection agent, anti-mould and above all as a cross linking agent in resin finishing (Piccinini et al. 2007).

Overall, Formaldehyde vapour is released by some textile finishes, such as those conferring crease resistance, while a garment is new. Formaldehyde is very water soluble, and washing new garments before wearing will generally reduce the amount of formaldehyde released from the fabric (Australian Government 2007).

The development and use of newer resins, overcoming the use of Formaldehyde, in clothing production to, impart durable press characteristics have addressed some of these issues as well as reducing the level of formaldehyde in clothing. These newer resins, also called cross-linking agents, became widely used in the 1980s. For example, dimethylol dihydroxy ethylene urea (DMDHEU) and its derivatives are reported to be the most commonly used resins today (Basant and Rani 2013).

Limits permitted of Formaldehyde in Textile and clothing products

A number of countries all over the world have been addressing the formaldehyde presence into textile products, thus setting limits for this presence by legacies; these limitations are detailed in Table 1 below.

Table 1: Egyptian and international formaldehyde limits in clothing and other textiles (parts per million (ppm))

Country	Level of formaldehyde
Australia	Textiles that contain 1500ppm or above must be labelled
China	Textiles for infants and babies ≤ 20ppm Textiles in direct skin contact ≤ 75ppm Textiles not in direct skin contact ≤ 300ppm
* Egypt	Textiles for babies and children ≤ 20ppm Textiles in direct skin contact ≤ 75ppm Textiles not in direct skin contact ≤ 300ppm
Finland and Norway	Textiles for babies under 2 years: 30ppm Textiles in direct skin contact :100ppm Textiles not in direct skin contact: 300ppm
France	For products intended to come in contact with human skin – Textiles for babies: 20ppm Textiles in direct skin contact :100ppm Textiles not in direct skin contact: 400ppm
Germany	Textiles that normally come into contact with the skin and release more than 1500ppm formaldehyde must bear the label "Contains formaldehyde> Washing this garment is recommended prior to first time use in order to avoid irritation of the skin."
Japan	Textiles for infants: not detectable (20ppm) Textiles in direct skin contact :75ppm
Netherlands	Textiles in direct skin contact must be labelled "Wash before first use" if they contain more than 120ppm formaldehyde and the product must not contain more than 120ppm after wash.
New Zealand	The amount of free and partly hydrolysable formaldehyde in the final fabric shall not exceed 30ppm for products that come into direct. There is also a voluntary Eco-labelling Trust "Textiles, Skins and Leathers" labelling standard.

Source: New Zealand Consumer affair 2007

* Source: ES 7266-2&4:2011

From the above, Table 1, various countries got different limits for formaldehyde percentage

within textile and clothing items, a number of countries do ask manufacturers for labeling products with formaldehyde, while other countries label new garments should be washed prior wear.

Table 2: Prohibited and limited chemicals and dyes intended for garments within the Egyptian market

	Chemicals or Dyes	Criteria (banned or limits)
1	Harmful Cancerous Dyes	Banned (Colour Index: basic red 9 – disperse blue 1 – acid red 26 – basic violet 14 – disperse orange 11 – direct black 38 – direct blue 6 – direct red 28 – disperse yellow 3)
2	Azo-dyes	Banned
3	Tris (Aziri Dinyl) Phosphin Oxide	Banned
4	Tris (2,3 Di Bromo Propyl) Phosphate	Banned
5	Poly Bromo Biphenyls; Poly brominated biphenyls (PBB)	Banned
6	Formaldehyde	Textiles: for babies and children ≤ 20ppm in direct skin contact ≤ 75ppm not in direct skin contact ≤ 300ppm
7	Phthalate in children's wear	≤ 0.1% of sample weight
8	Heavy metals used into dyes, prints and finishes	Cadmium: banned Nickel: emissions ≤ 0.5 µg/cm^2/week Lead (in children's wear): ≤ 300ppm

Source: ES 7266-4:2011

According to the ES 7266-2&4:2011 of the Egyptian Government there is a number of dyes and chemicals prohibited or got restrictions, as shown in Table 2, formaldehyde is one of those chemicals.

Health Effects of Formaldehyde in Textile and Clothing Products

The most likely health effects arising from release of formaldehyde from clothing textiles are irritation of eyes and nose of the wearer, and allergic reactions on skin in contact with the clothes. As a result of its solubility in water and high reactivity, formaldehyde is efficiently absorbed into the mucus layers protecting the eyes and respiratory tract where it rapidly reacts, leading primarily to localized irritation (Solman et al. 2008). Breathing formaldehyde vapour can result in irritation of nerves in the eyes and nose, which may cause burning, stinging or itching sensations, a sore throat, teary eyes, blocked sinuses, runny nose, and sneezing. Skin contact with formaldehyde can cause skin rashes and allergic skin reactions. The levels of exposure which may cause these allergic reactions will vary between individuals, and will depend on the individual's previous allergy history (Australian Government 2007). Children, especially those with diagnosed asthma, may be more likely to show impaired pulmonary function and symptoms than are adults following chronic exposure to formaldehyde (Solman et al. 2008). Instances of dermatitis arising from wearing clothing containing high levels of formaldehyde have been documented. Formaldehyde can have other health effects, but these occur at much higher levels than can be released from textile products. It is recommended that consumers with a history of allergy wash new garments prior to wearing (Australian Government 2007).

Methods used for determining Formaldehyde into textile and clothing products

A number of test methods are used to detect formaldehyde into textile and clothing products these are shown in Table 3

Table 3: Various test method determining formaldehyde in fabrics

Formaldehyde Testing Methods	Testing Standards
Released by sealed jar method	AATCC 112 BS EN 14184 - 2
Free & hydrolyzed method	BS EN 14184 - 1 Japanese law 112 (also known as JIS L 1041)
Qualitative analysis	Spot test

Source: Textile Testing International's Online Newsletter (March-April 2012)

Methods used worldwide to detect formaldehyde within textile products are the standard method EN ISO 14184-1&2; the free and hydrolyzed formaldehyde standard method EN ISO 14184-1 (water extraction method) is widely used, as it is considered to be easier in detecting formaldehyde rate than the vapour absorption, EN ISO 14184-2 (vapour absorption), which mimics possible exposure due to inhalation. The EN ISO 14184-1&2 methods detect formaldehyde on the fabrics between 20mg/kg and up to 3500mg/kg; lower than 20mg/kg is reported as Not Detectable. EN ISO 14184-1, water extraction standard method, principle is based on having, the 1gm to 2.5gm, specimen added to distilled water into a tube which by turn is put onto a water bath of 40°C, for 30min. the amount of formaldehyde hydrolysis is then determined, using spectrophotometer of the distilled water in comparison with another acetylacetone reagent. The vapour absorption method, EN ISO 14184-2, is based on suspending a weighed fabric specimen over water in a sealed jar, Figure 1.

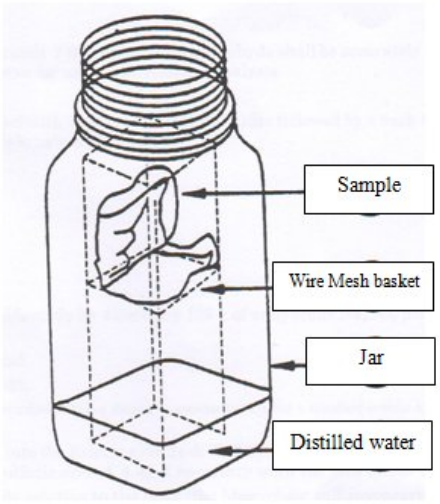


Figure 1: A tested specimen suspended in a wire mesh basket within a sealed jar
Source: EN ISO 14184-2:1998

The jar is then put into an incubator at a controlled temperature of 49°C, for 20hours. Then the formaldehyde absorbed by water is determined using spectrometer. This standard is determining formaldehyde released under accelerated storage from textiles by means of vapour absorption. This method is based on the AATCC method 112.

The two analytical tests now commonly used in the textile industry to identify levels of formaldehyde in clothing and textiles are the Japanese Industrial Standard (JIS L 1041) test, also known as the Japanese Law 112 test (Japanese test), and the American Association of Textile Chemists and Colourists 112 test (AATCC test). The main difference between these particular methods is that the Japanese test was developed to measure the amount of formaldehyde that may be released by clothing and other textiles that may come into contact with the skin, and the AATCC test was developed to measure the amount of formaldehyde that may be released from clothing and other textiles during extended storage or hot and humid conditions. Because of different testing specifications, as well as variables related to the particular formaldehyde resins used, formaldehyde levels measured by the two tests are not comparable, and the results from the Japanese test cannot be used to predict what the results would be under the AATCC test and vice versa. Equipment used is spectrophotometer and high-performance liquid chromatography (Basant and Rani 2013).

Japanese law 112 is concerned by simulated skin exposure to formaldehyde, this test method uses a water extraction and a spectrophotometer reading, as shown in Figure 2; which can pose a problem for fabrics that use certain softeners and direct dyes. These finishes can cause the extraction to be cloudy or tinted which can result in a false positive, results reported in ppm (parts per million).

Figure 2: Photo showing Japanese test method 112 Extractor and spectrophotometer

Released Formaldehyde is determined using AATCC Test Procedure 112 (Durbin Extraction). It is called a Sealed Jar Method providing an analytical means for determining the amount of formaldehyde released under the condition of accelerated storage. Simulated released formaldehyde – breathing exposure, uses an incubator, sealed jar and water bath which is then read on a spectrophotometer, as shown in Figure

3. This test method does not show cloudy or tinted extraction, results reported in ppm (parts per million). Acceptance criteria from AATCC 112 cannot be compared to Japanese Law Method.

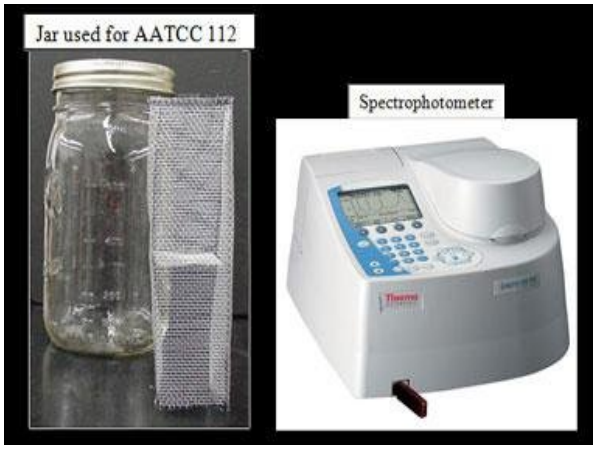


Figure 3: Photo showing AATCC test method 112 Jar and spectrophotometer

In 2010, as a conclusion of a research by the European Union detecting formaldehyde in textiles, to better simulate foreseeable conditions of use, the ideal solution seemed to use artificial perspiration solutions acidic and another alkaline instead of water as an extraction medium, together with stainless steel balls in washing machine vessels used originally for colour fastness test methods; giving both the sweating and rubbing effect a clothing item face during real wear, respectively. Also it was found that vapour absorption test method gave a higher amount of 30mg/kg (30ppm) released formaldehyde when compared to water extraction test method, for the same tested clothing items.

Spot test is a test method used to determine formaldehyde in textiles qualitatively. A square sample of 1inch^2 is used with reagents and consumables of dilute water, sulfuric acid (95 to 98%), phenyl hydrazine and anhydrous ferric chloride. For multi-colour fabric, selected tested sample should represent all colours of tested textile product. Report solution with pink colour denotes Positive presence of formaldehyde, no observed difference tells negative or less than 10ppm, finally, incase of fibre dissolving or colour leaching this indicates inconclusive results (TCF 2013).

Determining formaldehyde should always be tested on unconditioned samples; preliminary conditioning of textile samples may result on changes of formaldehyde content within a sample. Also the method or way by which sample was packed should be mentioned within laboratory report, finally the best way for packaging is plastic package and then wrapped by Aluminium foil (EN ISO 14184-1:1998).

Methodology

A number of Children's wear has been picked up from Egyptian market; thirty 100% cotton and cotton/blended products were included for inspection within the selected sample, number of garments with various fibre content of investigated garments is seen in Figure 4. All of which were top knitted items; dyed or printed garments, either dyed or printed tested garments is shown in Figure 5 and Figure 6 shows their shades. In regard to children, samples were purchased both for babies under the age of two while others for older children up to the age of 14, exact number of each age group is presented in Figure 7. Seven underwear and twenty three t-shirts were considered in this paper. All tested items were randomly selected from nine different retailers in Giza of Egypt. Those departmental stores are selected having various branches of at least the three major provinces in Egypt; Cairo, Alexandira and Tanta. Figure 8 represent garments' Country of Origin, while Figure 9 shows the range of prices where lower end and moderate markets have been considered. The acceptable testing method EN ISO 14184-1:1998 Textiles – Determination of Formaldehyde – Part 1: Free and Hydrolysed Formaldehyde (Water Extraction Method) was used to detect formaldehyde presence and percentage within tested samples; which tries to simulate the real conditions of use though an extraction in water at 40 °C.

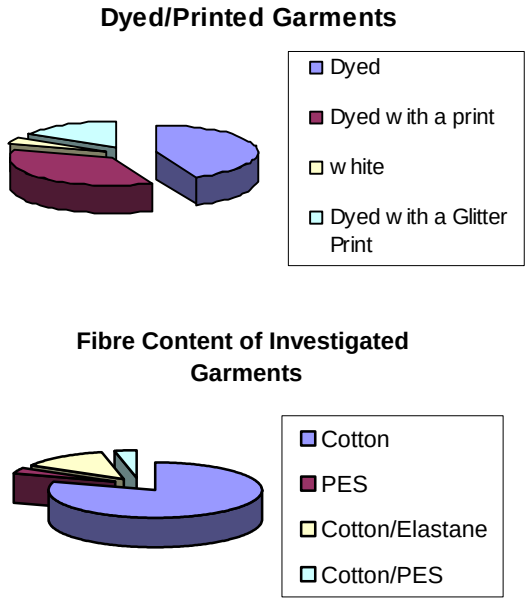
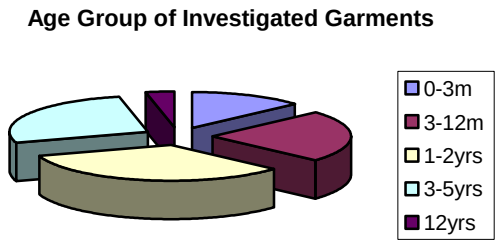


Figure 5



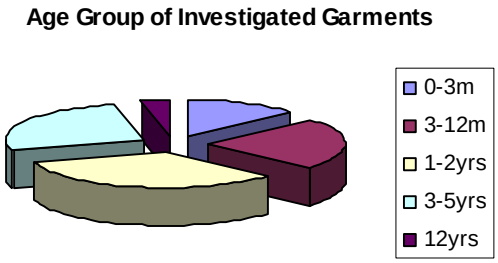
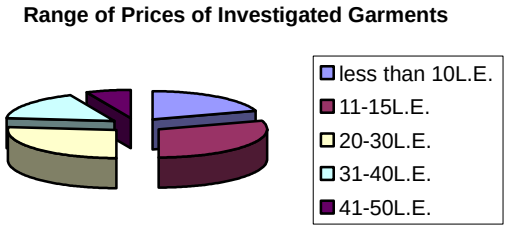


Figure 7



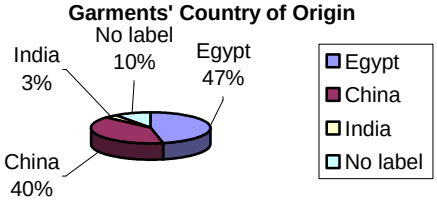


Figure 9

Results and discussion

Even though tested garments were selected through out the year 2013, from a reasonable number of retailers, with variables of colour shades and prints, all focused on children wear having into consideration all ages within childhood. The testing method EN ISO 14184-1:1998 Textiles – Determination of Formaldehyde – Part 1: Free and Hydrolysed Formaldehyde (Water Extraction Method), resulted on formaldehyde free articles, for all thirty tested garments with less than 16ppt. Low levels of formaldehyde in clothing, resulted into this research and addressed onto other according to government and trade publications, is industry actions to address concerns about some formaldehyde-containing resins. The older resins, such as urea formaldehyde and melamine formaldehyde, impart durable press characteristics to clothing but also tend to release more formaldehyde during the manufacture, storage, retailing, and use of fabrics and clothing than newer resins because they are less chemically stable. In addition, the older resins can also stiffen fabric, degrade after repeated washing, damage fabrics if chlorine bleach is used, and cause the fabrics to emit a noticeable odour (GAO 2010).

Resultant data, from this study, does show consistent relation with Egyptian laws regarding percentage of formaldehyde within clothing items intended for children, of formaldehyde free articles with $\leq$ 20ppm for all tested articles. More research should be undertaken investigating the other harmful chemicals and dyes banned or limited according to the ES 7266-4:2011, as well as percentage of formaldehyde onto woven articles either for children, women or men's wear.

Conclusion

During the past few years, formaldehyde percentages within clothing items were of a big concern by various researchers and governments. Due to the negative health influence these chemical emissions may cause owing to inhalation by consumers. Susceptible Children suffering asthma are prone to suffocation and skin irritation wearing items treated with formaldehyde added softeners, prints or other finishing agents.

Top knitted Children's wear within Egyptian market is formaldehyde free, not-detectable within tested samples. These items were selected randomly from various considerably cheap retailers, within the year of 2013. Items were from zero up to 12 years old children, printed dyed and white, country of origin was considered mainly from China and Egypt. It is recommended to extend research to cover other items as woven articles as well as menswear, women's wear and bed linings.

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Appendix (1)

Garment No.	Fibre content	Dyed/ printed	Shade	Age	Brand name	Retailer	Price L.E.	COO
G1	100% cotton	dyed	light	4yrs	Junior	Tawheed&Nour	12.25	Egypt
G2	100% cotton	dyed	Light	4yrs	Junior	Tawheed&Nour	12.25	Egypt
G3	100% cotton	dyed	Light	4yrs	Junior	Tawheed&Nour	13.00	Egypt
G4	100% cotton	dyed	light	4yrs	Junior	Tawheed&Nour	13.00	Egypt
G5	100% cotton	white	white	12yrs	Junior	Tawheed&Nour	26.00	Egypt
G6	100% cotton	Dyed with a print	deep	6m	Baby line	Texas	10.00	Egypt
G7	100% polyester	Dyed with a print	medium	6m	Hem valley	Texas	10.00	China
G8	100% cotton	Dyed with a print	medium	2yrs	Judy kidswear	Texas	10.00	Egypt
G9	95% cotton & 5%elastane	Dyed	light	1yr	NEXT	Texas	35.00	China
G10	65% cotton 35% polyester	Dyed	deep	1yr	NEXT	Texas	35.00	China
G11	100% cotton	Dyed	Light	0/3m	Spencer's	123 stock	6.50	China
G12	100% cotton	Dyed	Light	0/3m	Spencer's	123 stock	6.50	China
G13	100% cotton	Dyed	medium	0/3m	Spencer's	123 stock	6.50	China
G14	100% cotton	Dyed	Medium	3/6m	Jasper J Cohran	123 stock	25.0	Egypt
G15	1oo% cotton	Dyed	medium	3/6m	Jasper J Cohran	123 stock	25.0	Egypt
G16	96% cotton 4%elastane	Dyed with glittery print	medium	4yrs	Pravo	Stock house	29.0	china
G17	96% cotton 4%elastane	Dyed with glittery print	deep	4yrs	Pravo	Stock house	39.0	china
G18	100% cotton	dyed	deep	18m	chief	Stock house	49.0	No label
G19	100% cotton	Dyed with print	medium	2yrs	Pravo	Stock house	49.0	china
G20	100% cotton	Dyed with a print	medium	2yrs	Jeeplay	Stock house	29.0	china
G21	100% cotton	Dyed with a print	medium	2 yrs	Fabulous	Fabulous	24.00	Egypt
G22	100% cotton	Dyed with a print	medium	6/9 month	Fabulous	Fabulous	28.00	Egypt
G23	100% cotton	Dyed	medium	0/3 month	Not labelled	Nilestock	15.00	Egypt
G24	100% cotton	Dyed with a print	deep	4-5yrs	George.	Nilestock	15.00	Egypt
G25	100% cotton	Dyed with a print	Deep	3/6 month	Alana	Nilestock	15.00	No label
G26	100% cotton	Dyed with a print	Deep	3-4yrs	max	max	25.0	No label
G27	96% cotton 4% elastane	Dyed with a print	Deep	2yrs	Colm & Pear	Shaaban	35.0	No label
G28	100% cotton	Dyed 2 colours with a print	medium	2yrs	Al Qara kids wear	Shaaban	39.0	China
G29	100% cotton	Dyed with a print	Deep	3/6 month	Not labelled	Nile stock	15.0	china
G30	100% cotton	Dyed with a print	Deep	2 yrs	GATT	Nile stock	15.0	Egypt

Note: 1USA Dollar is almost equal to 7L.E. (Egyptian pounds), 1UK Pound is equal to 10L.E.