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2010–2020年红厚壳属植物化学成分及生物活性研究进展

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［摘要］红厚壳属植物资源丰富，植物中富含香豆素类、双苯吡酮类、黄酮以及萜类等化合物，具有抗肿瘤、抗HIV-1、抗炎、抑菌、抗氧化等药理作用。通过查阅和分析相关文献，对近10 a红厚属植物的化学成分和药理作用进行全面整理，旨在为该属植物的进一步研究和开发利用提供参考。

［关键词］红厚壳属；化学成分；药理活性
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A Review on Chemical Components and Bioactivities of Calophyllum Plants

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［**Abstract**］Plants in Calophyllum genus are rich in compounds including coumarins，xanthones，flavonoids and terpenoids，with pharmacological activities on anti-tumor，anti-HIV-1，anti-inflammatory，antibacterial and antioxidative effect. In order to provide directions for the further research of the Calophyllum genus，we reviewed studies on the chemical constituents and pharmacologyfrom year 2010–2020.

［**Key words**］Calophyllum；Chemical constituent；Pharmacological activity

红厚壳属（Calophyllum）植物为藤黄科（Guttiferae）常青乔木，全世界有180~200种，主要分布在马来西亚、菲律宾、印度、斯里兰卡等亚热带地区，其次则分布在南美洲和大洋洲[1]。我国主要有4种：红厚壳（Calophyllum inophyllum linn）、薄叶红厚壳（Calophyllum membranaceum）、兰屿红厚壳（Calophyllum blancoi）和滇南红厚壳（Calophyllum polyathum），主要分布在海南、广西南部、云南南部及台湾[2]。

自1993年Patil等[3]从Calophyllum inophyllum中分离得到具有显著的抑制HIV逆转录酶活性的香豆素类化合物inphyllum B和inophyllum P以来，国外学者对红厚壳属植物的化学成分进行了大量的研究，分离得到香豆素类（Coumarins）、双苯吡酮类（Xanthones）、黄酮类（Flavonoids）、萜类（Terpenoids）等多种类型化合物[4-5]。经现代药理学研究表明，红厚壳属植物药用活性成分具有抗肿瘤、抗HIV-1、抗菌、抗炎、抗氧化等多种生物活性，极具研究和开发价值。因此，本文就红厚壳属植物的化学成分和生物活性研究作一综述。

1 红厚壳属的化学成分与分布

红厚壳属植物主要含有香豆素类、双苯吡酮类、黄酮类、萜类等多种类型化合物。

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1.1 香豆素类（Coumarins）

香豆素类化合物具有苯骈 α－吡喃酮母核，可视为邻羟基桂皮酸形成的内酯，环上常含有羟基、烷氧基、苯基、异戊烯基等取代基。红厚壳属植物中的香豆素类成分的结构按内酯环上取代基不同，可分为三类：丙基取代、苯基取代、甲基取代香豆素[6]，见表1。

表1 红厚壳属植物中的香豆素类化合物

编号	化合物名称	来源	参考文献
1	Apetalolide	C. dioscurii	[7]
2	Methyl inophyllum P	C. dioscurii	[7]
3	Calopolynolide B	C. depressinervosum	[8]
4	Benjaminin	C. benjaminum	[9]
5	Gracilenins A	C. gracilentum	[10]
6	Gracilenins B	C. gracilentum	[10]
7	Gracilenins C	C. gracilentum	[10]
8	Inophyllum H	C. inophyllum	[11]
9	Inophyllum I	C. inophyllum	[11]
10	Inophyllum J	C. inophyllum	[12]
11	12–O–Butylinophyllum D	C. inophyllum	[11]
12	12–O–Ethylinophyllum D	C. inophyllum	[11]
13	(–)–12–Methoxyinophyllum A	C. inophyllum	[12]
14	(+)–12–Methoxyinophyllum H–1	C. inophyllum	[12]
15	(–)–12–Methoxyinophyllum H–2	C. inophyllum	[12]
16	Hoseimarin	C. hosei	[13]
17	Incrassamarin A	C. incrassatum	[1]
18	Incrassamarin B	C. incrassatum	[1]
19	Incrassamarin C	C. incrassatum	[1]
20	Incrassamarin D	C. incrassatum	[1]
21	Iso–soulattrolide	C. symingtonianum	[14]
22	Soulamarin	C. soulattri	[15]
23	Wallimarin T	C. wallichianum	[16]
24	7,4'–Dihydroxy–6,8–dimethoxy–4–phenylcoumarin	C. polyanthum	[17]
25	7–Hydroxy–6,8,4'–trimethoxy–4–phenylcoumarin	C. polyanthum	[17]
26	7–Hydroxy–4'–methoxy–4–phenylcoumarin	C. polyanthum	[17]
27	6,7–Dihydroxy–4'–methoxy–4–phenylcoumarin	C. polyanthum	[17]
28	α–Hydroxytomentolide A	C. apetalum	[18]
29	5,7–Dihydroxy–6–(3–methylbutyryl)–4–phenylcoumarin	C. sclerophyllum	[19]
30	7,8–Dihydro–5–hydroxy–7,8–dimethyl–4–propyl–2H,6H–benzo[1,2–b;5,4–b']dipyran–2,6–dione	C. incrassatum	[1]

1.2 双苯吡酮类（Xanthones）

双苯吡酮类又称呫吨酮、氧杂蒽酮、苯骈色原酮等，具有苯骈－γ－吡喃酮环的基本骨架。双苯吡酮类化合物具有多样的取代基结构及不同的取代模式，且其母核容易发生扭曲变化，也有一些双苯吡酮类化合物[20]，见表2。

1.3 苯并二氢吡喃 –4– 酮类（4–chromanones）

苯并二氢吡喃 –4– 酮又称 4– 二氢色原酮，红厚壳属中的苯并二氢吡喃 –4– 酮类化合物，见表3。

表 2　红厚壳属植物中的双苯吡酮类化合物（1）

编号	化合物名称	来源	参考文献
1	1,6–Dihydroxy–5,7–dimethoxyxanthone	C. ceriferum	[22]
2	1,7–Dihydroxy–2,3,8–trimethoxyxanthone	C. ceriferum	[22]
3	1,3,7–Trihydroxy–8–methoxyxanthone	C. inophyllum	[23]
4	1, 3, 6–Trihydroxy–5–methoxy–xanthone	C. membranaceum	[24]
5	1, 3, 7–Trihydroxyxanthone	C. membranaceum	[24]
6	1–Hydroxy–6, 7–dimethoxyxanthone	C. membranaceum	[24]
7	1, 4, 5–Trihydroxyxanthone	C. membranaceum	[24]
8	2–Deprenyl–rheediaxanthone B	C. inophyllum	[23]
9	2–Hydroxy–1–methoxyxanthone	C. inophyllum	[23]
10	2–Hydroxy–1,8–dimethoxyxanthone	C. inophyllum	[23]
11	3, 5– Dihydroxyxanthone	C. austroindicum	[24]
12	4–Hydroxy–3–methoxyxanthone	C. membranaceum	[24]
13	6–Hydroxy–2,3–dimethoxyxanthone	C. inophyllum	[23]
14	7–Hydroxy–1,3–dimethoxyxanthone	C. inophyllum	[23]
15	1,6–Dihydroxy–5–methoxy–8–(2–methyl–2–oxo–3–butenyl)–40,40,50–trimethyl–dihydrofurano(20,30:3,4)xanthone	C. inophyllum	[25]
16	7,9,12–Trihydroxy–2,2–dimethyl–2H,6H–pyrano[3,2–b]xanthen–6–one	C. elatum	[26]
17	12b–Hydroxy–des–D–garcigerrin A	C. elatum	[26]
18	Dulciol E	C. elatum	[26]
19	Ananixanthone	C. venulosum	[27]
20	Buxixanthone	C. buxifolium	[28]
21	Caloxanthone I	C. venulosum	[27]
22	Caloxanthone O	C. inophyllum	[21]
23	Caloxanthone P	C. inophyllum	[21]
24	Caloxanthone Q	C. inophyllum	[29]
25	Caloxanthone T	C. inophyllum	[23]
26	Calophylixanthones A	C. membranaceum	[30]
27	Calophylixanthones B	C. membranaceum	[30]
28	Calotetrapterin A	C. tetrapterum	[31]
29	Calotetrapterin B	C. tetrapterum	[31]
30	Calotetrapterin C	C. tetrapterum	[31]
31	Calothorexanthone	C. thorelii	[32]
32	Calaxanthone C	C. calaba	[34]
33	Fuscaxanthone C	C. benjaminum	[9]
34	Garbogiol	C. thorelii	[32]
45	Globuxanthone	C. thorelii	[32]
46	Isogarciniaxanthone E	C. elatum	[26]

表 2 红厚壳属植物中的双苯吡酮类化合物（2）

编号	化合物名称	来源	参考文献
37	Inophinnin	C. inophyllum	[35]
38	Inophinone	C. inophyllum	[36]
39	β–Mangostin	C. hosei	[13]
40	Nodusuxanthone	C. nodusum	[23]
41	Osajaxanthone	C. hosei	[13]
42	Phylattrin	C. soulattri	[37]
43	Soulattrin	C. soulattri	[38]
44	Symphoxanthone	C. elatum	[26]
45	Rheediaxanthone A	C. inophyllum	[36]
46	Thorexanthone	C. thorelii	[32]
47	Tovopyrifolin C	C. venulosum	[27]
48	Venuloxanthone	C. venulosum	[27]
49	Xanthochymone B	C. depressinervosum	[8]

表 3 红厚壳属植物中的苯并二氢吡喃 –4– 酮类化合物

编号	来源	来源	参考文献
1	Apetalic acid	C. brasiliense	[39]
2	Brasiliensic acid	C. brasiliense	[40]
3	Isobrasiliensic acid	C. brasiliense	[40]
4	Blancoic acid	C. castaneum	[19]
5	Isoblancoic acid	C. castaneum	[19]
6	Calopolyanic acid	C. polyanthum	[41]
7	Isocalopolyanic acid	C. polyanthum	[41]
8	Isorecedensic acid	C. polyanthum	[41]
9	Calopolyanic acid methyl ester	C. membranaceum	[30]
10	Isopinetoric acid methyl ester	C. membranaceum	[30]
11	Isoapetalic acid	C. antillanum	[43]
12	Calodryobalanoic acid	C. dryobalanoides	[42]
13	Calolongic acid	C. Pinetorum& C. teysmannii	[43– 44]
14	Isocalolongic acid	C. Pinetorum&C. teysmannii	[43– 44]
15	Caloteysmannic acid	C. teysmannii	[44]
16	Caloinophyllin A	C. inophyllum	[45]
17	Caloinophyllin B	C. inophyllum	[46]
18	Isopinetoric acid III	C. pinetorum	[43]

2 药理作用

2.1 抗肿瘤活性

2010 年，Dai 等[21]从 C. inophyllum 中分离得的双苯吡酮类化合物 caloxanthone O 对人胃癌细胞（SGC–7901）有细胞毒性，其 IC_{50} 为 22.4 μg/mL。2011 年，魏代静等[23]从 C. inophyllum 中分离得的双苯吡酮类化合物 1，3，5–trihydroxy–2 – methoxy – xanthone 同样对人胃癌细胞（SGC–7901）的增殖显示出生长抑制活性，其 IC50 值为 1.8×10^{-5} mol/L。

2017 年，Shanmugapriya 等[47]研究发现 C. inophyllum 果实提取物不仅可以在 G_0/G_1 期和 G2/M 期诱导细胞周期停滞和凋亡，而且可通过增强细胞内活性氧，干扰正常的线粒体膜电位和激活 Caspase–3 来影响线粒体的凋亡途径，进而对

MCF–7 细胞具有显著的抗肿瘤活性，IC_{50} 值为 23.59 μg/mL。

2018 年，Sichaem 等[46]使用 MTT 比色法评估从 C. inophyllum 分离的 18 个化合物对人口腔表皮样癌细胞（KB）和人宫颈腺癌细胞（HeLa S–3）的体外细胞毒性活性，其中双苯吡酮类化合物 1，6–dihydroxy–7–methoxyxanthone 对人口腔表皮样癌细胞（KB）和人宫颈腺癌细胞（HeLa S–3）显示中等活性，IC50 值分别为 25.8 和 18.1 μM。Kar Wei 等[48]对 C. teysmannii 中分离出双苯吡酮类化合物 ananixanthone 以及通过对其乙酰化，甲基化和苄基化作用得到的四个衍生物进行人胃癌细胞（SNU–1）和人慢性髓性白细胞（K562）细胞毒性活性测试。测试显示，Ananixanthone 的细胞毒性优于其他衍生物，IC_{50} 值分别为（8.97 ± 0.11）和（2.96 ± 0.06）μg/ mL，侧链的修饰并没有增强其对这两种癌细胞系的细胞毒性。

2.2　抗炎活性

2011 年，Ee 等[35]从 C. inophyllum 茎皮分离得的双苯吡酮类化合物 inophinnin，其具有抗炎活性。2012 年，Tsai 等[49]在脂多糖（LPS）诱导的 RAW 264.7 细胞上测试了 C. inophyllum 丙酮提取物的抗炎活性，结果表明 C. inophyllum 提取物通过抑制 iNOS 和 COX–2 的表达以及 miR–146a 的表达而具有很强的抗炎作用。2014 年，Zakaria 等[50]研究发现 C. inophyllum 果实提取物具有抗炎作用，50 μg/mL 的 C. inophyllum 粗提物对环氧合酶和脂氧合酶活性的抑制率分别为 77%和 88%。2017 年，Nguyen 等[51]发现 C. inophyllum 种子的主要成分香豆素 Calophyllolide 具有抗炎活性，其能诱导抗炎细胞因子 IL–10 的表达，同时抑制促炎细胞因子 IL–1β，IL–6，TNF–α 的表达。

2.3　抗菌活性

2010 年，Mishra 等[52]发现与 C. inophyllum 茎皮氯仿提取物相比，甲醇提取物对革兰氏阳性菌和革兰氏阴性菌有明显的抗菌作用。研究表明，C. inophyllum 茎皮的甲醇提取物在 25.0 μg/mL 浓度对铜绿假单胞菌、金黄色葡萄球菌和表皮葡萄球菌具有显著的抗菌作用，在 50.0 μg/mL 浓度对地衣芽孢杆菌、枯草芽孢杆菌、大肠杆菌和肺炎克雷伯菌具有显著的抗菌作用。2012 年，Alkhamaiseh 等[53]对 C. canum 三种不同极性组分提取物进行蜡状芽孢杆菌、金黄色葡萄球菌、大肠杆菌、铜绿假单胞菌、白色念珠菌和新生隐球菌抗菌试验，发现其中正己烷组分对蜡样芽孢杆菌的活性最高，MIC 和 MBC 分别为 12.5 μg/mL 和 100.0 μg/mL，DCM 组分对金黄色葡萄球菌的活性更强，MIC 为 50.0 μg/mL。2018 年，Susanti 等[54]采用纸片扩散法检测从 C. symingtonianum 的茎皮中分离得到的香豆素类化合物 12–O–ethylinophyllum D 和 iso–soulattrolide 对金黄葡萄球菌、蜡状芽孢杆菌、大肠杆菌和铜绿假单胞菌的抑菌活性，结果表明两个化合物对铜绿假单胞菌均有抑制作用，MIC 为 111.0 μg/mL，iso–soulattrolide 对金黄葡萄球菌也具有抑制活性，MIC 为 25.0 μg/mL。

2.4　抗氧化活性

2012 年，Prasad 等[55]发现，从 C. inophyllum 叶中分离得的三萜类化合物 Canophyllic acid 和黄酮类化合物 Calophyllic acid 与 Isocalophyllic acid 的混合物具有很好的抗氧化活性。2015 年，Aminudin 等[56]研究发现 C. symingtonianum 和 C. depressinervosu 甲醇提取物均具有清除 DPPH 自由基能力，C. symingtonianum 心材提取物的 IC50 为（5.17 ± 0.04）μg/mL，C. symingtonianum 叶提取物的 IC50 为（15.70 ± 1.43）μg/mL，C. depressinervosu 树皮提取物的 IC_{50} 为（5.17 ± 0.04）μg/mL。2019 年，Rachmani 等[33]测试了 C. soulattri 叶乙醇提取物的总黄酮含量和清除 DPPH 自由基能力，研究显示总黄酮含量为（25.677 ± 0.046）%，IC_{50} 为（39.63 ± 14.99）ppm。

3　小结

综上所述，随着分离、纯化和鉴定技术的发展与应用，国外学者不仅从红厚壳属植物中不断分离出新的香豆素、双苯吡酮类、黄酮等化学成分，而且对其药理活性进行了大量研究，对开发天然安全有效的抗肿瘤、抗 HIV–1、抗炎、抗菌和抗氧化药物具有重要意义。在前人的基础上对该属植物的化学成分及其药理活性进行深入研究，对于合理开发利用红厚壳属植物资源具有重要意义。

[参考文献]

[1] Aminudin N I, Ahmad F, Taher M, et al. Incrassamarin A D: four new 4–substituted coumarins from calophyllum incrassatum and their biological activities [J]. Phytochemistry Letters, 2016, 16(6): 287–293.

[2] 中国科学院中国植物志编辑委员会. 中国植物志[M]. 北京:科学出版社, 1990: 82.

[3] Patil A D, Freyer A J, Eggleston D S, et al. The inoph yllu–

ms,novel inhibitors of HIV-1 reverse transcriptase isolated from the malaysian tree,calophyllum inophyllum Linn[J]. Journal of Medicinal Chemistry,1993,36 (26): 4131-4138.

[4] Ee G C L,Mah S H,Rahmani M,et al. A new furanoxanthone from the stem bark of Calophyllum inophyllum[J]. Journal of Asian Natural Products Research,2011,13(10): 956-960.

[5] Su X H,Zhang M L,Li L G,et al. Chemical constituents of the plants of the genus calophyllum [J]. Chemistry & Biodiversity,2008,5(12): 2579-2608.

[6] Ishikawa T. Anti HIV-1 active Calophyllum coumarins: Distribution,chemistry,and activity [J]. Heterocycles, 2000,53(2): 453-474.

[7] Tjahjandarie T S,Tanjung M,Rahmania D F,et al. Calodioscurins A and B,two new isoprenylated xanthones from the stem bark of calophyllum dioscurii P.F. Stevens[J]. Natural Product Research,2019,33(8):1-6.

[8] Masters K S,Brase S. Xanthones from fungi,lichens,and bacteria:The natural products and their synthesis [J]. Chemical Reviews,2012,112(7): 3717-3776.

[9] Sahimi M S M,Ee G C L,Mahaiyiddin A G,et al. A new natural product compound benjaminin from calophyllum benjaminum [J]. Pertanika Journal of Tropical Agricultural Science,2015,38(1):1-6.

[10] Lim C K,Ham Y P,Lim L Q,et al. 4-Alkylcoumarins and a phloroglucinol from the stem bark of calophyllum gracilentum [J]. Phytochemistry Letters,2019,30 (4): 99-102.

[11] Jian Zou,Jian Wu,Shuang-Zhu Liu,et al. New coumarins and triterpenes from calophyllum inophyllum[J]. Helvetica Chimica Acta,2010,93(9):1812-1821.

[12] Li Z,Li Y,Qin N,et al. Four new coumarins from the leaves of calophyllum inophyllum [J]. Phytochemistry Letters, 2016,16(6): 203-206.

[13] Daud S B,Ee G C L,Malek E A,et al. A new coumarin from calophyllum hosei [J]. Natural Product Research, 2014,28(19): 1534-1538.

[14] Susanti D,Attoumani N,Taher M,et al. A conformational isomer of soulattrolide from the stem bark of calophyllum symingtonianum and its antibacterial activity [J]. Natural Product Sciences,2018,24(1): 47-53.

[15] Ee G C L,Mah S H,Teh S S,et al. Soulamarin,a new coumarin from stem bark of calophyllum soulattri [J]. Molecules,2011,16(11): 9721-9727.

[16] Tee K H,Ee G C L,Ismail I S,et al. A new coumarin from stem bark of calophyllum wallichianum[J]. Natural Product Research,2018,32(21): 2565-2570.

[17] Zhong H,Ruan J L,Yao Q Q. Two new 4-arylcoumarins from the seeds of calophyllum polyanthum [J]. Journal of Asian Natural Products Research,2010,12(7): 562-568.

[18] Joshi S P,Kulkarni S R,Phalgune U D,et al. New dipyranocoumarin from the leaves of calophyllum apetalum willd [J]. Natural Product Research,2013,27(20): 1896-1901.

[19] Lim C K,Hemaroopini S,Gan S Y,et al. In vitro cytotoxic activity of isolated compounds from malaysian calophyllum species [J]. Medicinal Chemistry Research,2016,25(8): 1686-1694.

[20] Masters K S,Brase S. Xanthones from fungi,lichens,and bacteria: The natural products and their synthesis [J]. Chemical Reviews,2012,112(7): 3717-3776.

[21] Dai H F,Zeng Y B,Xiao Q,et al. Caloxanthones O and P: two new prenylated xanthones from calophyllum inophyllum [J]. Molecules,2010,15(2):606-612.

[22] Hang N T M,Van Hung N,Chien N Q. Xanthones from the twigs of the vietnamese calophyllum ceriferum gagnep. Ex Stevens [J]. Vietnam Journal of Science and Technology, 2012,50(5): 615-619.

[23] 魏代静,曾艳波,梅文莉,等. 红厚壳枝条的化学成分[J]. 热带亚热带植物学报,2011,19(4):355-359.

[24] 虞俊,宋鑫明,陈光英. 薄叶红厚壳根的呫吨酮成分(英文)[J]. 中国天然药物,2010,8(06):433-435.

[25] Li Z L,Liu D,Li D Y,et al. A novel prenylated xanthone from the stems and leaves of calophyllum inophyllum[J]. Natural Product Research,2011,25(9): 905-908.

[26] Ito C,Matsui T,Kobayashi T,et al. Cancer chemopreventive activity of xanthones from calophyllum elatum [J]. Natural Product Communications,2018,13(4): 447-449.

[27] Ismail A A F,Ee G C L,bin Daud S,et al. Venuloxanthone,a new pyranoxanthone from the stem bark of calophyllum venulosum [J]. Journal of Asian Natural Products Research,2015,17(11): 1104-1108.

[28] Daud S,Ee G C L,Abd Malek E,et al. A new pyranoxanthone from the stem bark of calophyllum buxifolium[J]. Chemistry of Natural Compounds,2016,52(5): 807-809.

[29] Wei D J,Mei W L,Zhong H M,et al. A new prenylated xanthone from the branches of calophyllum inophyllum[J]. Journal of Asian Natural Products Research,2011,13(03): 265-269.

[30] Ming M,Zhang X,Chen H F,et al. RXRα transcriptional inhibitors from the stems of calophyllum membranaceum [J]. Fitoterapia,2016,108(1): 66-72.

[31] Tanjung M,Tjahjandarie T S,Saputri R D,et al. Calotetrapterins A-C,three new pyranoxanthones and their cytotoxicity from the stem bark of calophyllum tetrapterum Miq [J]. Natural Product Research,2021,35(3): 407-412.

[32] Nguyen L T T,Nguyen D M,Nguyen L H D. A new xanthone from the bark of calophyllum thorelii [J]. Natural Product Research,2013,27(6): 563-567.

[33] Rachmani E P N,Baroroh H N,Rehana R,et al. Antiradical scavenging activity and total flavonoid content of slatri leaves extract (CalophyllumsoulattriBurm. f)[J]. Annals of

Tropical Medicine and Health, 2019, 22(11): 183–189.

[34] Laopian F, Kaennakam S, Rassamee K, et al. Calaxanthones A–C, three new xanthones from the roots of calophyllum calaba and the cytotoxicity [J]. Natural Product Research, 2019, 33(11): 1584–1590.

[35] Ee G C L, Mah S H, Rahmani M, et al. A new furanoxanthone from the stem bark of calophyllum inophyllum[J]. Journal of Asian Natural Products Research, 2011, 13(10): 956–960.

[36] Mah S H, Ee G C L, Teh S S, et al. Calophyllum inophyllum and calophyllum soulattri source of anti–proliferative xanthones and their structure　activity relationships[J]. Natural Product Research, 2015, 29(1): 98–101.

[37] Nguyen L T T, Nguyen H T, Barbi M, et al. Polyisoprenylated acylphloroglucinols and a polyisoprenylated tetracyclic xanthone from the bark of calophyllum thorelii[J]. Tetrahedron Letters, 2012, 53(34): 4487–4493.

[38] Mah S H, Ee G C L, Rahmani M, et al. A new pyranoxanthone from calophyllum soulattri [J]. Molecules, 2011, 16(5): 3999–4004.

[39] C é sar G Z J, Alfonso M G G, Marius M M, et al. Inhibition of HIV–1 reverse transcriptase, toxicological and chemical profile of calophyllum brasiliense extracts from Chiapas, Mexico[J]. Fitoterapia, 2011, 82(7): 1027–1034.

[40] Lemos L M S, Oliveira R B, Sampaio B L, et al. Brasiliensic and isobrasiliensic acids: isolation from calophyllum brasiliense Cambess. and anti–Helicobacter pylori activity [J]. Natural Product Research, 2016, 30(23): 2720–2725.

[41] Wang H, Sun Q Y, Yang F M, et al. Chromanone derivatives from the pericarps of calophyllum polyanthum[J]. Helvetica Chimica Acta, 2010, 93(11): 2183–2188.

[42] Ha L D, Hansen P E, Duus F, et al. A new chromanone acid from the bark of calophyllum dryobalanoides [J]. Phytochemistry Letters, 2012, 5(2): 287–291.

[43] Piccinelli A L, Kabani A O, Lotti C, et al. A fast and efficient HPLC–PDA　MS method for detection and identification of pyranochromanone acids in calophyllum species [J]. Journal of Pharmaceutical and Biomedical Analysis, 2013, 76(3): 157–163.

[44] Lim C K, Subramaniam H, Say Y H, et al. A new chromanone acid from the stem bark of calophyllum teysmannii [J]. Natural Product Research, 2015, 29(21): 1970–1977.

[45] Ponguschariyagul S, Sichaem J, Khumkratok S, et al. Calophyllin A, a new chromanone derivative from calophyllum inophyllum roots [J]. Natural Product Research, 2018, 32(21): 2535–2541.

[46] Sichaem J, Tippyang S, Siripong P, et al. Chemical constituents from the root bark of calophyllum inophyllum[J]. Natural Product Communications, 2018, 13(6): 727–729.

[47] Shanmugapriya, Chen Y, Kanwar J R, et al. Anticancer activity and molecular mechanism of polyphenol rich calophyllum inophyllum fruit extract in MCF–7 breast cancer cells[J]. Nutrition and Cancer, 2017, 69(8): 1308–1324.

[48] Kar Wei L, Zamakshshari N H, Ee G C L, et al. Isolation and structural modifications of ananixanthone from calophyllum teysmannii and their cytotoxic activities[J]. Natural Product Research, 2018, 32(18): 2147–2151.

[49] Tsai S C, Liang Y H, Chiang J H, et al. Anti–inflammatory effects of calophyllum inophyllum L. in RAW264. 7 cells [J]. Oncology Reports, 2012, 28(3): 1096–1102.

[50] Zakaria M B, Ilham Z, Muhamad N A. Anti–inflammatory activity of calophyllum inophyllum fruits extracts [J]. Procedia Chemistry, 2014, 13(1): 218–220.

[51] Nguyen V L, Truong C T, Nguyen B C Q, et al. Anti–inflammatory and wound healing activities of calophyllolide isolated from calophyllum inophyllum Linn [J]. PloS One, 2017, 12(10): e0185674.

[52] Mishra U S, Murthy P N, Choudhury P K, et al. Antibacterial and analgesic effects of the stem barks of calophyllum inophyllum[J]. International Journal of Chemical Technology Research, 2010, 2(2): 973–979.

[53] Alkhamaiseh S I, Taher M, Ahmad F, et al. The phytochemical content and antimicrobial activities of malaysian calophyllum canum (stem bark)[J]. Pakistan Journal of Pharmaceutical Sciences, 2012, 25(3): 555–563.

[54] Susanti D, Attoumani N, Taher M, et al. A conformational isomer of soulattrolide from the stem bark of calophyllum symingtonianum and its antibacterial activity [J]. Natural Product Sciences, 2018, 24(1): 47–53.

[55] Prasad J, Shrivastava A, Khanna A K, et al. Antidyslipidemic and antioxidant activity of the constituents isolated from the leaves of calophyllum inophyllum [J]. Phytomedicine, 2012, 19(14): 1245–1249.

[56] Aminudin N I, Ahmad F, Taher M. In vitro antioxidant, cholinesterase and tyrosinase inhibitory activities of Calophyllum symingtonianum and calophyllum depressinervosum (Guttiferae)[J]. Journal of Coastal Life Medicine, 2015, 3(2): 126–131.