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Modeling the growth of Indian and Chinese liquid crystals literature as reflected in Science Citation Index (1997–2006)

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Abstract The present paper describes the application of growth models as suggested by Egghe and Ravichadra Rao (Scientometrics 25:5–46, 1992). The scope of the paper is limited to study the growth and dynamics of Indian and Chinese publications in the field of liquid crystals research (1997–2006).

Keywords Scientometrics · Modeling the growth · Liquid crystals

Introduction

Scientists have known about liquid crystals since the end of the nineteenth century. Austrian botanist Friedrich Reinitzer first noted the phenomenon in 1888. He observed that a material known as cholesteryl benzoate had two distinct melting points. In his experiments, Reinitzer increased the temperature of a solid sample and watched the crystal change into a hazy liquid. As he increased the temperature further, the material changed again into a clear, transparent liquid. Because of this early work, Reinitzer is often credited with discovering a new phase of matter—the liquid crystals phase. The subsequent studies of Lehmann, a physicist from Germany (1889, 1900, 1904), Schenk (1905) Vorländer (1908) and Friedel (1922) established that the intermediate phases of this and a number of other compound represent new states of matter that are quite distinct from the amorphous liquid phase. The first Indian research work on the subject was reported only in the 1950s by Dave from Baroda (Chandrasekhar 1996). He conducted systematic studies on synthesis of compounds and on phase diagrams of binary mixtures. Over the past three decades, a variety of well known theoretical as well as experimental contributions have been made, including synthesis and physical studies on liquid crystals. While Indian and Chinese

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fundamental studies on liquid crystals have had an international impact, applied work in this field has been on a low key. RRI and Bharat Electronics Limited cooperated to develop an indigenous know how for the manufacture of simple LCD devices, which are being produced for commercial applications.

One of the features of modern research in recent years has been the spectacular development in scientific discoveries and growth of knowledge. This has caused an unexpected accumulation of information. Hence, there is a need to study this growth of knowledge and its dynamics, Price (1975) has suggested the need for measuring science, using quantitative methods.

Objectives of the study

The main objectives of the study are:

(a) to find the applicability of selected growth models to the growth of Indian and Chinese publications; and
(b) to verify the criteria for selecting the most appropriate growth model suggested by Egghe and Ravichadra Rao (1992).

Methodology

The data was retrieved from the Science Citation Index Expanded, published by Thomson Reuters. By using suitable search strategy related to liquid crystals (related keywords: liquid crystals or mesogens or mesomorphic or smectic or banana shaped or nematic phase or chiral phase or lyotropic or lamellar or thermotropic or discotic phase were used) field, records pertaining to India and China in the author affiliation field were collected for the period 1997–2006. The methodology suggested by Egghe and Ravichadra Rao (1992) for selecting an appropriate growth model from several competing models on a data relating to publication growth has also been utilized.

Egghe and Ravichadra Rao (1992) have proposed a methodology for identification and classification of growth models, based on two new proposed growth rate functions ($\propto_1$ and $\propto_2$). They have also derived the graphs of these two growth rate functions for the four growth models, namely exponential, logistic, power and Gompertz. In order to get a clue to the selection of the best growth model, the plots or two growth rate functions for different mathematical models are presented and visualized in terms or the following classification type: Type-1 increasing; Type-2 constant; Type-3 decreasing; and Type-4 increasing and then decreasing, as shown in Table 1, it has been observed in the earlier studies (Sangam and Keshava 2003; Sangam et al. 2007), that second growth rate function ($\propto_2$) is a better predictor of likely model to fit in the data than the first growth function ($\propto_1$). Therefore, in the present study the second growth function is used.

Results and discussion

Growth pattern of publications

During 10 years span time (1997–2006) India has contributed a total of 1567 (3.46%) with the average number of publications per year was 156.5 and the highest number of

Table 1 Classification of mathematical growth models based on growth rate functions

Types of model	Growth rate functions	
	μ_1	μ_2
Exponential	Type 2	Type 1
Logistic or Gompertz ($0 < A, B > 1$)	Type 3	Type 4
Gompertz ($A, B > 1$)	Type 1	Type 1
Power ($\propto > 0, 0 < \gamma \leq 1$)	Type 3	Type 1
Power ($\propto > 0, \gamma > 1$)	Type 4	Type 1
Power ($\propto = 0$)	Type 3	Type 2

Table 2 Year-wise distribution of Indian, Chinese and other countries scientists' contribution to liquid crystals in terms of input of publications to SCI (1997–2006)

Publication year	Input by world	Cumulative total	Cumulative %	Input by China	Input by India	Total	Cumulative total	Cumulative %
1997	4190	4190	9.27	143	129	272	272	5.50
1998	4078	8268	18.29	173	98	271	543	10.99
1999	4309	12577	27.81	234	119	353	896	18.13
2000	4484	17061	37.73	275	127	402	1298	26.26
2001	4778	21839	48.30	314	178	492	1790	36.22
2002	4418	26257	58.07	303	170	473	2263	45.79
2003	4621	30878	68.29	408	170	578	2841	57.49
2004	4929	35807	79.19	472	193	665	3506	70.94
2005	4907	40714	90.04	518	192	710	4216	85.31
2006	4503	45217	100.00	535	191	726	4942	100.00
Total	45217	45217	100	3375	1567	4942	4942	100

publications was found 193 during 2004 and 2006. China has contributed a total of 3375 (7.46%) with the average number of publications per year was 337.5 and the highest number of publications was 535 in 2006. The total number of publications in-put by countries other than India and China i.e. rest of the world, including international organizations was 45217. The highest number of input of publications by other countries was 4929 in 2004. Table 2 shows year-wise growth of Indian and Chinese publications in liquid crystals field.

The productive year of Indian scientists in terms of number of publications are 2005 (192), 2001 (178), 2002 (170), 1997 (129), 2000 (127). The productive years of Chinese Scientists during 2005 was 514, 2004 (417), 2003 (408), 2001 (314) and 2002 (303).

To select an appropriate growth models to the Indian and Chinese cumulative growth of publications in liquid crystals literature (1997–2006) indicate that a number of the growth models were evaluated in terms of their model parameters, fit statistics of the data. Power and growth models in the period 1997–2001 and linear, power and growth models in the period 2002–2006 showed best fits in growth of Indian liquid crystals research publications. In case of growth of Chinese liquid crystals literature, the best fits were shown by power and growth models in the period 1997–2001 and linear, power and growth models in the period 2002–2006, as shown in Table 3.

To select the most appropriate model, the plot of second growth rate function ($\propto_2$) was examined. These results, as seen through visual inspection of the plots of the second

Table 3 Fit statistics derived from the application of various models to the Indian and Chinese cumulative growth of publications in 1997–2006

Period	Best results obtained in Indian literature		Best results obtained in Chinese literature	
	Name of model	R^2	Name of model	R^2
1997–2001	Power	0.99938	Power	0.99797
	Growth	0.99937	Growth	0.99799
2002–2006	Linear	0.99719	Linear	0.99947
	Power	0.99782	Power	0.9983
	Growth	0.99779	Growth	0.99827

growth rate function ($\propto_2$) of the Indian and Chinese cumulative publications data in the period 1997–2006, indicates as follows:

(i) The plots of the second growth rate function ($\propto_2$) derived from growth data of Indian liquid crystals literature in all 10 years can be interpreted as constant (Type 2).
(ii) The plots of the second growth rate function ($\propto_2$) derived from growth data of Chinese liquid crystals publications shown increasing (Type 1) in the period 1997–2006.

Conclusion

On comparing the results obtained from actual statistical fits of the different growth models and the most appropriate growth model likely to fit, as reflected in the plots of second growth rate function of liquid crystals literature during the period 1997–2006, it is concluded that Power and growth models are likely to be fully applicable in growth of Indian, and linear, power and growth models fully applicable in growth of Chinese liquid crystals literature (It is a short communication hence the Figures not included in the paper).

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